



Surveys and Needs Assessments

Survey of farmers' knowledge of yam pests and diseases and management practices in southern Ethiopia

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Yam is a widely consumed food in the tropics and subtropics. Determination of pests (pathogens and insects) and diseases (developed pest invasions and symptoms) and the appropriate management practices are critical in existing crop production systems. This study aimed to document farmers' knowledge about yam pests and diseases and their management practices in southern Ethiopia. Data were collected from 342 systematically selected farmers and 96 yam fields in 5 major yam-growing zones (Dawuro, Gofa, Gamo, Kembata-Tembaro, and Wolaita) in southern Ethiopia using a semi-structured interview guide. The results showed that 54.1% of the farmers saved their planting materials for the next growing season, while 39.2% of the farmers purchased the planting materials from the local market every year. Most farmers (63.5%) reported that the cultivation of yam has been declining annually due to pests and diseases. White yam (*Dioscorea rotundata*) (POIR, DIOSCOREALES, DIOSCOREACEAE) and water yam (*Dioscorea alata*) are severely damaged by pests and diseases, as perceived by 33.9% and 24.9% of farmers, respectively. Farmers use healthy-looking pest- and disease-free tubers (39.5%), remove infected plants (24.0%), practice crop rotations (17.3%), and use animal manure (7.0%) to manage yam pests and diseases. Farmers' knowledge can be a starting point for seeking solutions to yam pests and disease risks. This study could play an important role in improving yam cultivation by identifying strategies to improve the recent decline in yam production to meet future food needs for a rapidly growing population.

Key words: disease, farmer, management, pest, yam

Introduction

Yams (*Dioscorea* spp.) are classified in the *Dioscoreaceae* family and are represented by more than 800 species (Lebot 2009). Of these, only 10 species (*D. alata*-water yam, *D. bulbifera*-aerial yam, *D. cayenensis*-yellow yam, *D. dumetorum*-bitter yam, *D. esculenta*-Chinese yam, *D. rotundata*-white yam, *D. japonica*-glutinous/Japanese yam, *D. trifida*-Indian yam/cush-cush, *D. oppositifolia*-Chinese yam, and *D. nummularia*-Pacific/spiny yam) are edible (Tamiru et al. 2007, Acina et al. 2014, Luo et al. 2022). Among these species, *D. bulbifera*, *D. abyssinica*, and *D. schimeriana* are distributed in many savanna regions of Africa, and *D. rotundata* is the most preferred and cultivated species, accounting for a large proportion of yam production in the world (Westphal 1975, FAO 2017).

Ethiopia is generally considered an isolated centre of yam cultivation "outside the yam belt" in West Africa (Zhang and Norman 1995). Yam is the most important crop for food security in the southern, southwestern, and western regions of the country (Tamiru et al. 2007). It is considered an insurance crop against food insecurity and a preferred crop in agricultural systems due to its narrow requirement for production inputs (Bekele and Bekele 2020). Yam species such as *D. bulbifera*, *D. abyssinica*, and *D. schimeriana* are native to Ethiopia (Westphal 1975). Other yam species, such as *D. alata*, *D. esculenta*, and *D. rotundata*, are also widely cultivated annually by subsistence farmers, particularly in the main yam-growing areas of Ethiopia (Tamiru et al. 2007, Mekbib and Deressa 2016, Bekele and Bekele 2020).

Several biotic and abiotic constraints have been identified as deterrents to yam production, the most important of which are pests, such as insects, pathogens (bacteria, fungi, viruses, and protozoa), and diseases (caused by invasions of pests and identified by symptoms developed) (Asiedu and Sartie 2010, Kolade et al. 2022). According to Kolade et al. (2022), 50%–90% of the losses in yam tuber yield occur due to pests and diseases, which can harm yam tubers by decreasing their content of dry substances, therefore decreasing the sprouting capacity and diminishing quality by making them unsuitable for consumers (Andres et al. 2017). Diseases may begin at the time of sprouting and continue through maturity and harvest. These impediments challenge food security and farmers' ability to generate sustainable incomes that can be earned from yam cultivation (Tamiru et al. 2007, FAO 2017).

Southern Ethiopia is one of the major yam-producing areas in the country. Farmers in this region have a wealth of knowledge about yam cultivation practices that have been passed down through generations. Farmer knowledge is a type of local knowledge, which is relevant when linked to a particular local context. Farmers' knowledge involves dynamic processes and complex systems of experiences, practices, and skills developed and sustained by people in their environmental and socioeconomic realities (Klein et al. 2023). Farmers' perceptions offer useful information on yam cultivation practices, the distribution of yam pests and diseases, and management practices (Munyuli et al. 2017). Yam is a widely consumed food in the Dawuro, Gofa, Gamo, Kembata-Tembaro, and Wolaita zones of the region. However, farmers' knowledge about yam cultivation, the

distribution of yam pests and diseases, and management practices have not been documented. This study was initiated to document the knowledge of farmers about yam cultivation, determination of yam pests and diseases, and management practices in the main yam growing areas in southern Ethiopia.

Materials and Methods

Study Area Surveyed

This study was carried out in 5 major yam cultivation zones of southern Ethiopia (Dawuro, Gamo, Gofa, Kembata-Tembaro, and Wolaita) in 2021/2022 (Fig. 1). The zones were selected based on their high yam cultivation records. The altitude ranges from 1,200 to 3,500 m above sea level, with the average annual temperature and rainfall in the surveyed areas ranging from 13 to 32 °C and from 7,500 to 1,800 mm, respectively (Table 1). The ideal period for sampling was from March to May. The sampling timing was consistent for each zone.

Sample Size Determination and Sampling Techniques

Kebeles (the smallest administrative units) were randomly selected from a list of the main yam producing communities provided by the agricultural development offices of the district in each zone. A total of 342 respondents were selected based on the sampling technique formula $n = z^2 pq / e^2$, where n : the sample size required; z : (1.96)—the

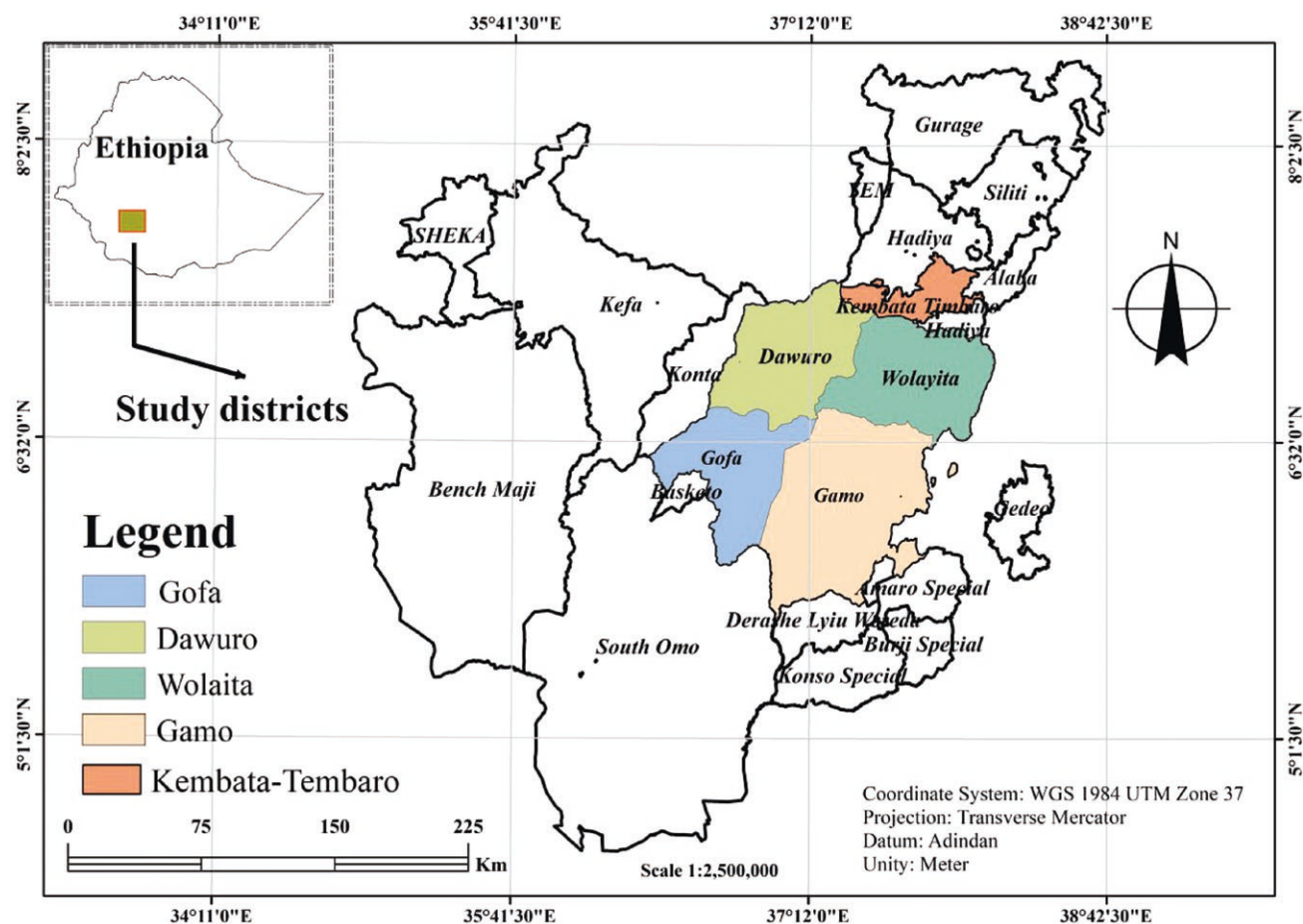
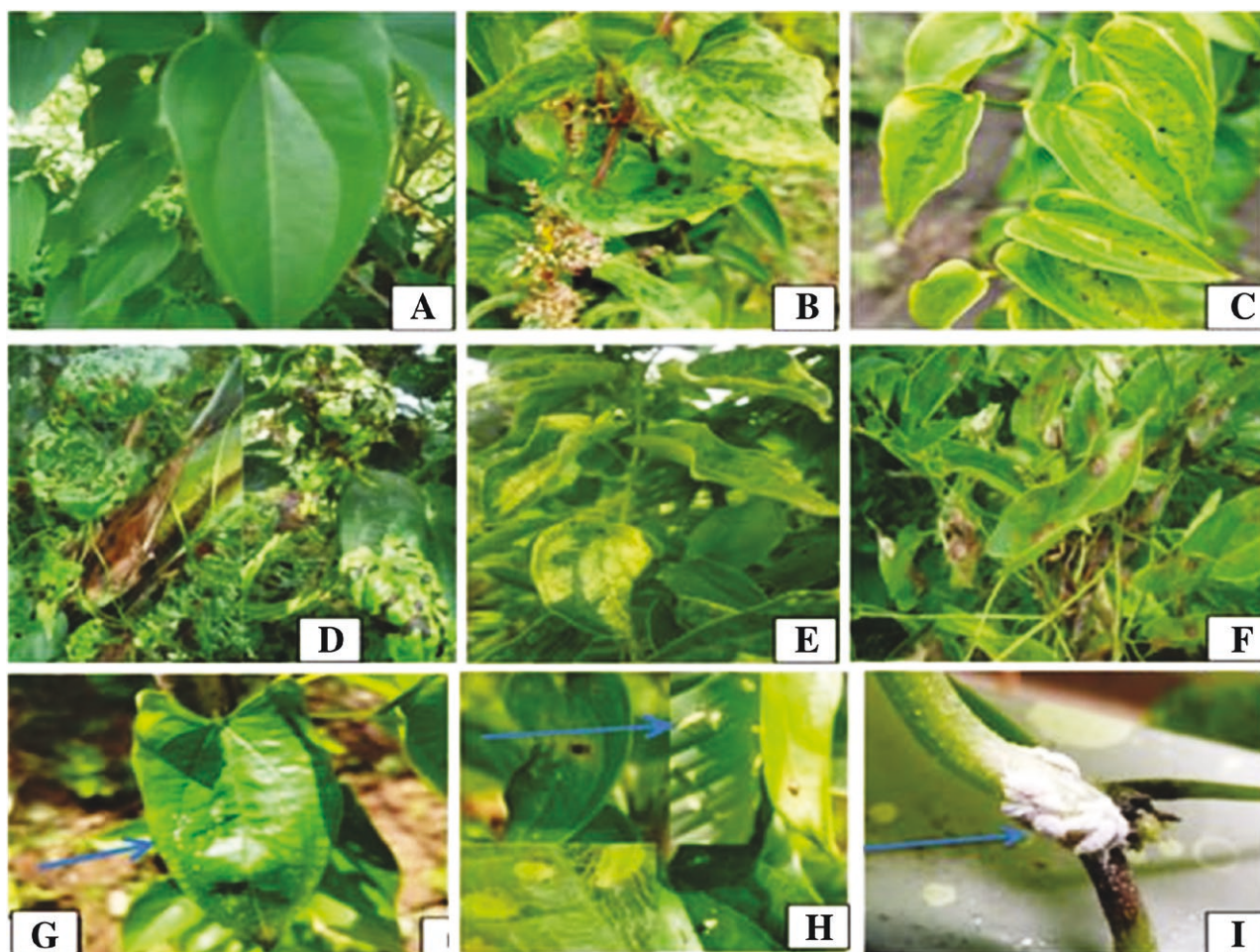


Fig. 1. Map of the survey areas in southern Ethiopia for study of farmers' knowledge about yam cultivation and the distribution of yam pests and diseases.

Table 1. Summary of the study area profiles on yam diseases surveillance study in southern Ethiopia (2021/2022)

Study zones	Number of respondents	Latitude	Longitude	Altitude (m.a.s.l ^a)	Temperature range (°C)	Average rainfall (mm)
Dawuro	51	6°35'–7°34'N	36°04'–37°53'E	1,501–3,000	15–28	1,201–1,800
Gamo	86	6°37'–7°37'N	35°55'–37°00'E	1,600–3,300	17–31	750–1,300
Gofa	68	6°25'–6°29'N	36°55'–36°89'E	1,200–2,660	18–32	900–1,700
Kembata-Tembaro	34	7°60'–7°75'N	37°38'–37°49'E	1,500–3,500	13–28	1,001–1,400
Wolaita	103	6°54'–6°83'N	37°45'–37°75'E	1,500–2,738	16–30	1,200–1,300

^aMeters above sea level.**Fig. 2.** Yam leaves showing pest and/or disease symptoms: non-symptomatic (healthy looking) A), mosaics B), chlorosis C), black lesions D), mottling E), necrosis F), aphid infestation G,H), mealybugs infestations I).**Table 2.** Selected study zones and sociodemographic characteristics of the respondents ($n = 342$) in southern Ethiopia

Zone	Gender		Education			Head of household		Age (years)	
	Female	Male	NFE	1 st edu	2 nd edu	Yes	No	Range	Average
Dawuro ($N = 51$)	11 (21.6)	40 (78.4)	25 (49)	17 (33.3)	9 (17.7)	40 (78.4)	11 (21.6)	27–70	49.3
Gamo ($N = 86$)	15 (17.4)	71 (82.6)	37 (43)	38 (44.2)	11 (12.8)	71 (82.6)	15 (17.4)	30–78	44.1
Gofa ($N = 68$)	12 (17.6)	56 (82.4)	34 (50)	25 (36.8)	9 (13.2)	57 (83.8)	11 (16.2)	29–68	39.8
Kembata-Tembaro ($N = 34$)	8 (23.5)	26 (76.5)	15 (44.1)	15 (44.1)	4 (11.8)	31 (91.2)	3 (8.8)	33–67	43.9
Wolaita ($N = 103$)	22 (21.4)	81 (78.6)	38 (36.9)	46 (44.7)	19 (18.5)	88 (85.4)	16 (14.6)	32–85	47.0
Total ($N = 342$)	68 (19.9)	274 (80.1)	149 (43.6)	141 (41.2)	52 (15.2)	289 (84.5)	53 (15.5)	27–85	44.8

Numbers in parentheses are the percentage of respondents. N, number of respondents; NFE, not formally educated; 1stedu, primary education; 2ndedu, education secondary and above.

critical value at 95% confidence level; p : an estimated proportion; q : $1-p$, and e : the error margin that is 0.05, as described by Cochran (1963). The assumed P value is 66.7% based on an earlier data

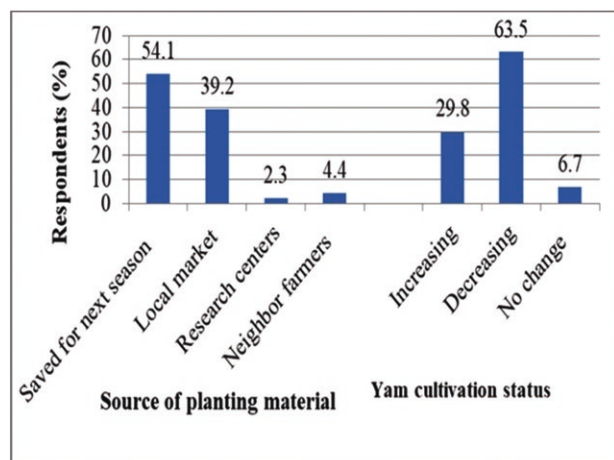


Fig. 3. Respondents observation concerning the source of planting materials and yam cultivation status in southern Ethiopia, 2021/2022.

report by Gogile et al. (2024a). All respondents who cultivate yam were listed to obtain a sampling frame. Then they were selected using systematic sampling techniques (where every n th element from a population is selected) from the sample frame and responded to the interview.

Survey Data Collection

A pre-tested semi-structured interview guide was used for data collection to contextualize the variables using input from farmers and agricultural professionals. Open and close-ended questions were included in the interview guide to gather primary data from farmers. An intensive house-to-house interview was conducted by knowledgeable enumerators in the respondent's native languages (Dawuro, Gofa, Gamo, Kembata, Tembaro, and Wolaita). A verbal agreement was obtained from the local authorities, and farmers were informed of the purpose of the interview before administering the interview. The interview questionnaires were 2 parts: the general sociodemographic part and the objective part of the research. The sociodemographic part consists of the list of factors such as age (years), sex (male or female), household heads (father, mother, or anyone with a yam farm), and marital status (single, married, divorced). Furthermore, the sociodemographic factors consisted of

Table 3. Summary of pests and diseases based on chi-square test with regards to farmers' sociodemographic characteristics, and study zones

No	Parameters	Sex			Age			Education			Zones		
		χ^2	df	P-value	χ^2	df	P-value	χ^2	df	P-value	χ^2	df	P-value
1	Yam cultivation practices	1.08	1	0.58	10.84	3	0.0001	4.96	2	0.08	634.06	4	0.0001
2	Recognition of yam pests and diseases	0.04	1	0.85	0.48	3	0.49	3.61	2	0.06	4.32	4	0.04
3	Yam pests and disease management methods	1.45	5	0.08	0.00	5	0.0001	0.71	5	0.02	0.00	5	0.0001

df, degree of freedom; χ^2 , chi-square value.

Table 4. Mean value of farmers' yam cultivation practices, area coverage, and annual yam production in southern Ethiopia

Zone	Farmers' yam cultivation experience (years)		Hectares of yam cultivation		yam annual production (kg/ha)	
	Range	Mean	Range	Mean	Range	Mean
Dawuro	7–37	35.21	0.05–0.17	0.056	1,112–3,375	2,133.84
Gamo	10–56	34.43	0.05–0.16	0.098	1,032–3,532	2,169.36
Gofa	9–37	30.18	0.05–0.15	0.076	1,107–3,372	2,140.94
Kembata-Tembaro	11–44	37.62	0.05–0.10	0.084	567–2,341	1,715.82
Wolaita	20–74	39.58	0.08–0.20	0.114	2,836–3,782	2,421.79
Total	7–74	35.80	0.05–0.15	0.079	567–3,782	2,116.35

Table 5. The criteria of farmers' preferences for yam tubers plantation by zone, age, and education in southern Ethiopia

Farmers' preference of yam ^a	N = 342	Zones (%)					Age of respondents (%)				Education of respondents (%)		
		DW	GM	GF	Km	WL	18–29	30–49	50–69	≥70	NFE	1'edu	2'edu
Resistance to pests & diseases	73 (21.3)	29.4	29.1	23.5	32.4	16.5	19.9	36.7	31.1	29.6	29.5	25.5	36.5
Market demand	112 (32.7)	39.2	41.9	33.8	41.2	35.0	33.2	40.0	37.8	44.4	34.9	43.3	38.8
Early mature	109 (31.9)	29.4	36.0	25.0	23.5	39.8	33.3	30.1	43.2	29.6	36.9	38.3	32.7
No of harvests per year	45 (13.2)	11.8	17.4	25.0	17.6	9.7	13.3	18.4	8.1	0.0	10.1	14.9	21.2
Weight of individual tuber	26 (7.6)	9.8	2.3	1.5	2.9	5.8	4.4	7.7	1.4	3.7	4.7	3.5	9.6

N, number of respondents; DW, Dawuro; GM, Gamo; GF, Gofa; KT, Kembata-Tembaro; WL, Wolaita; NFE, not formally educated; 1'edu, primary education; 2'edu, secondary education or above.

^aSingle or more than single options can be selected.

education level with different categories: not formally educated (not attending any school), primary (grade 1–8), secondary education (grade 9–12), and above secondary education (Diploma, degree etc.). For the objective part, the farmers were asked about the local name(s) of the yam, the source of the planting material, the preferred cultivars, and the cultivation of the yam. Participants were also asked about yam pests and diseases, their perceptions of any changes in disease incidence on their farms, indicators of yam pests and diseases, and management practices used to conserve yam species and eliminate yam pests and diseases. Ninety-six yam fields were surveyed at approximately 4–8 km intervals, as described by Khan and Damalas (2015) and Frimpong et al. (2021). Pests and their invasions were assessed, and disease symptoms (mosaics, mottles, chlorosis, necrosis, black lesions, tuber rot, and stunted growth) were recorded (Fig. 2) (Houngue et al. 2018). In this paper, we have used the term pest to refer to all pathogens and insects, while the term disease was used to refer to adverse pest inventions and symptoms developed.

Data Analysis

Descriptive statistical analysis and analyses of variance (ANOVA) were performed using the Statistical Package for Social Scientists version 20 (IBM 2013). Mean comparisons were made at the probability level of 0.05 to evaluate significant differences between means. A chi-square test was conducted to establish links between the sociodemographic characteristics of the farmers and their knowledge of the spread and control of yam pests and diseases. A correlation analysis was performed between farmer perceptions of yam pests and diseases and researchers' pests and diseases records. Results are presented as frequencies and percentages of respondents.

Results

Sociodemographic Characteristics of the Respondents

Of the 342 respondents, 68 (19.9%) were women, and 274 (80.1%) were men. Most of the respondents interviewed (84.5%) were household heads. The median age of the farmers was 44.8 years, ranging from 27 to 85 years. The average yam cultivation experience of the farmers interviewed was greater than 7 years. More than half of the farmers (56.43%) had completed primary education or higher (Table 2).

Planting Materials, Hectare, and Annual Yam Production

A little over half, 185 (54.1%) of the farmers saved their planting materials for the next growing season, while 134 (39.2%) purchased them from the local market. Only 4.4% and 2.3% of the farmers obtained planting materials from the neighboring farmers and agricultural research centers, respectively (Fig. 3). Most farmers (63.5%) replied that yam cultivation was decreasing annually. As a function of year, the farmer's age was inversely proportional to the practice of yam cultivation, which differed significantly by age ($\chi^2 = 10.84$, $df = 2$, $P < 0.0001$) and study zone ($\chi^2 = 634.06$, $df = 2$, $P < 0.0001$) (Table 3).

The average land area allocated by farmers for yam cultivation was 0.079 ha, and the average annual yam production was 2,116.35 kg/ha. All the farmers interviewed had grown yam on land less than 1 ha. According to available farming information, the minimum average annual yam production was 1,715.82 kg/ha in the Kembata-Tembaro zone, and the maximum average annual yam

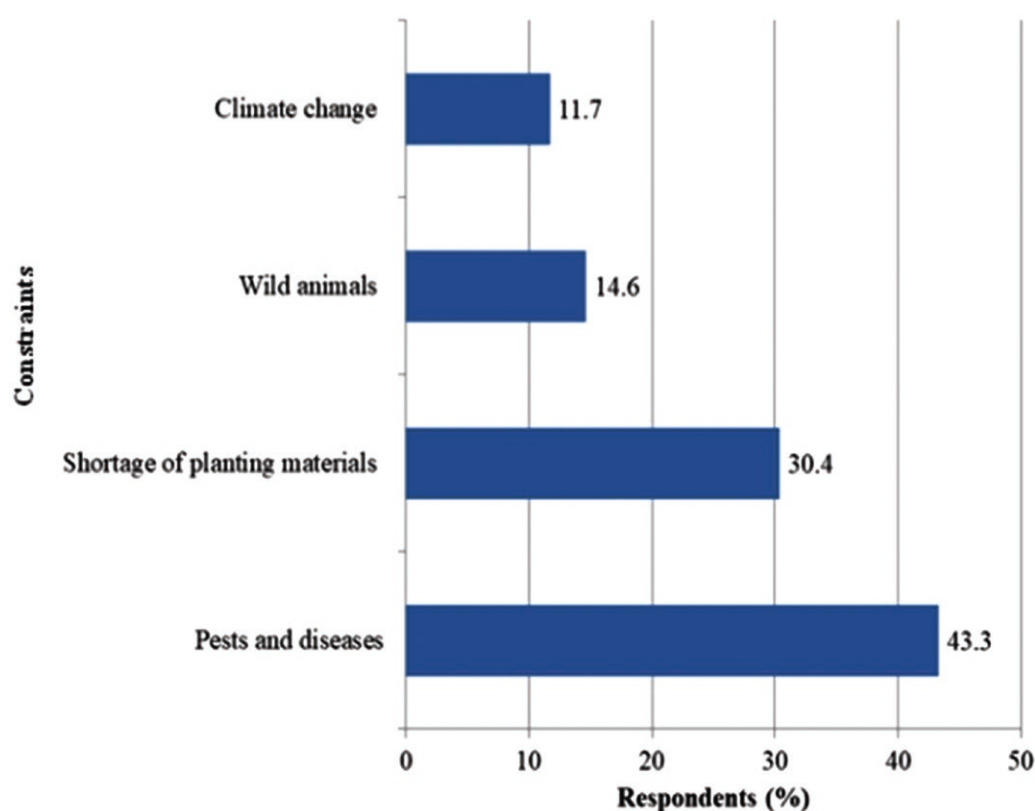


Fig. 4. Respondents ratio concerning constraints of yam production in southern Ethiopia, 2021/2022.

Table 6. Respondents ratio concerning yam pests and diseases incidences and their effects in southern Ethiopia

Variable (<i>n</i> = 342) Items	Overall (%)	Respondents proportion (%) in different profiles														
		Sex		Ages of respondent (%)				Education of respondents (%)				Zones				
		M	F	18–29	30–49	50–69	>70	NFE	1 ^{edu}	2 ^{edu}	DW	GM	GF	KT	WL	
Did you notice pest or disease symptom on the yam field in last 6 years?																
Yes	208 (60.8)	60.8	59.5	65.8	72.1	71.6	75.6	55.6	65.8	71.6	74.7	76.8	70.9	73.5	79.4	
No	134 (39.2)	39.2	40.5	34.2	27.9	28.4	24.4	44.4	34.2	28.4	25.3	23.2	29.1	26.5	20.6	
Have you observed any more damaged yam varieties by pests and diseases on the field?																
Yes	290 (84.8)	88.7	73.5	82.2	87.2	82.4	77.8	67.8	70.2	75.0	84.3	84.8	88.7	73.5	82.2	
No	52 (15.2)	11.3	26.5	17.8	12.8	17.6	22.2	32.2	29.8	25.0	15.7	15.2	11.3	26.5	17.8	
Would you list severely damaged yam varieties?																
Hatiya (<i>D. rotundata</i>)	116 (33.9)	33.6	26.5	37.8	37.2	41.9	51.9	24.8	31.2	44.2	31.4	36.0	33.8	38.2	34.0	
Unikuruwuba/Unikuruba/Bundubuchia/Dorsita (<i>D. bulbifera</i>)	16 (4.7)	6.6	5.9	2.2	4.1	0.0	3.7	4.0	4.3	1.9	0.0	2.3	2.9	0.0	5.8	
Gena, Gaffella (<i>D. alata</i>)	85 (24.9)	26.6	23.5	26.7	34.7	36.5	29.6	28.9	24.8	36.5	27.5	33.7	30.9	35.3	32.0	
Gebiche, Tolla-1, Bunne-2 (<i>D. abyssinica</i>)	47 (13.7)	11.3	13.2	4.4	5.6	10.8	11.1	15.4	10.6	9.6	9.8	14.0	10.3	2.9	7.8	
Arfa-1, Wancharo (<i>D. cayennensis</i>)	55 (16.1)	11.7	19.1	17.8	6.6	6.8	3.7	17.4	12.8	7.7	17.6	9.3	13.2	14.7	13.6	
Bunne 1, Arkiya, Gonchu kotine, Tolla (<i>D. Praehensilis</i>)	23 (6.7)	10.2	11.8	11.1	11.7	4.1	0.0	9.4	16.3	0.0	13.7	4.7	8.8	8.8	6.8	

NFE, not formally educated; 1^{edu}, primary education; 2^{edu}, secondary education or above; DW, Dawuro; GM, Gamo; GF, Gofa; KT, Kembata-Tembaro; WL, Wolaita.**Table 7.** Growth stage (months) vs. pests and diseases symptoms development ratios in yams in southern Ethiopia

Growth stage (months)	Respondents (%)	
	Pests symptoms	Diseases symptoms
Young stage (<5)	25.4	15.5
Maturation time (6–10)	44.4	47.1
Harvesting time(>10)	30.1	37.4
	$\chi^2 = 20.12, df = 2,$ $P < 0.0001$	$\chi^2 = 53.74, df = 2,$ $P < 0.0001$

production was 2,421.79 kg/ha in the Wolaita zone (Mulualem et al. 2022) (Table 4).

Farmers' Preference for Yam Species for Planting

More than 32.7%, 31.9%, 21.3%, 13.2%, and 7.6% of the farmers preferred yam species for planting according to their market demand, early maturity, resistance to pests and diseases, number of harvests per year, and weight of individual tubers, respectively (Table 5). When deciding on a yam crop for their livelihood, 33.8% of farmers in the Gofa zone and 41.9% in the Kembata-Tembaro zone prioritized market demand, while 25% in the Gofa zone and 39.8% in the Wolaita zone prioritized early maturity. A proportion of 40, 43.2, and 44.4 of 30–49, 50–69, and >70-year-old farmers selected yam for its market demand, early maturity, and market value, respectively. Farmers who received formal education prefer yam resistant to pests and diseases and market value, while not formally educated farmers prefer yam species for market demand and early maturity (Table 5).

Constraints of Yam Production

A large proportion of farmers (43.3%) selected pests and diseases as the main constraints on yam production. A shortage of planting material was the second major constraint cited by 30.4% of the respondents, but 11.7% and 14.6% of the respondents mentioned climate change (increased temperature and inconsistency of rainfall) and attack by other non-insect animals, respectively, as a common constraint on yam production (Fig. 4).

Identification of Yam Pests and Diseases and Their Effects

Most farmers (60.8%) reported that they recognized yam pests and diseases in their yam fields. Older and formally educated farmers responded that they notice pests and disease symptoms compared to younger and not formally educated farmers (Table 6). Based on farmer responses, significant differences in yam pests and disease distributions were recorded between zones ($\chi^2 = 4.32, df = 1, P < 0.05$) (Table 3). Among the respondents in the surveyed zones, a large number of farmers interviewed in the Wolaita zone (79.4%) and Gamo (76.8%) noted that they recognized pests and disease symptoms in the last 6 years (Table 6). During the survey period, 6 species of yams (*D. rotundata*, *D. alata*, *D. bulbifera*, *D. praehensilis*, *D. cayennensis*, and *D. abyssinica*), which are called by different local names in different zones, were observed (Table 6). Among these, *D. rotundata* and *D. alata* were the most common yam species affected by pests and disease, as indicated by the higher percentages of respondents (33.9% and 24.9%, respectively), which was confirmed by field observation during the survey. A lower percentage

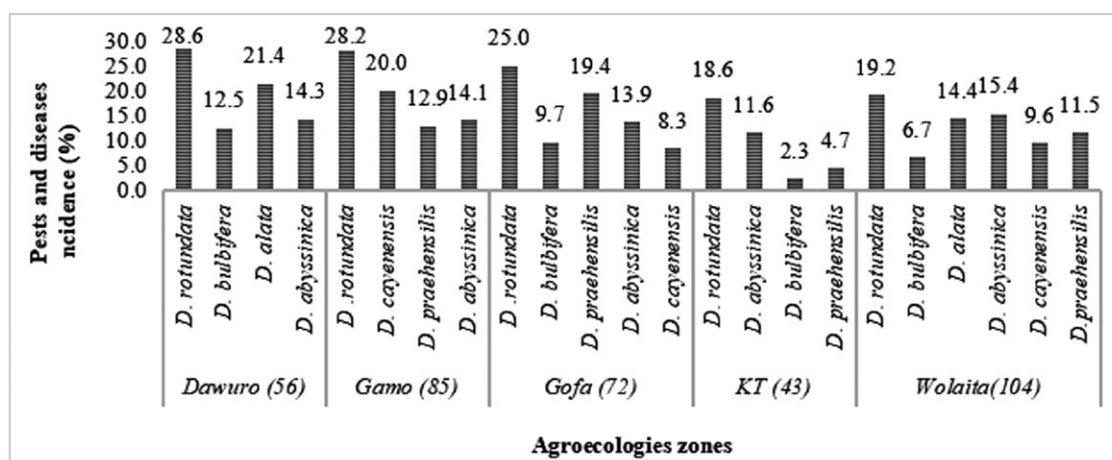


Fig. 5. Pests symptoms incidences recorded in southern Ethiopia, 2021/2022.

of farmers in all surveyed zones reported that *D. bulbifera* and *D. praehensilis* were affected by pests and diseases (Table 6).

Most farmers (44.4% and 47.1%) responded that they observed pests and disease damage in the maturation stage of yam growth. A sizable proportion of farmers reported that pests and diseases damage yam plants at the harvest stage. A considerable number of farmers also replied that they rarely observe yam pests and diseases in the early stages of yam growth (Table 7).

Pests and Diseases in the Surveyed Fields

A total of 96 yam fields were surveyed, and 360 yam leaf samples were collected. The highest percentage (28.9%) of leaf samples was collected in the Wolaita zone, while the lowest (16.7%) of leaf samples were collected in the Kembata-Tembaro zone based on their abundance at the time of the survey. Pests and diseases were observed in 71.7% of the surveyed yam fields. Most pests and diseases (28.6% of the Dawuro collection and 28.2% of the Gamo collection) were recorded in *D. rotundata*, while *D. bulbifera* generally had the lowest disease incidence recorded (2.4% of the yam collection from the Kembata-Tembaro zone) (Fig. 5).

An analysis of the correlations between farmer views and the results of the researcher's field survey revealed a positive relationship ($r = 0.62$). Most farmers have experienced poor yam yields for the past 6 years due to pests and diseases. The researchers also observed that poor yam yields during the survey indicated that disease and pests were the most important challenges to yam production in the surveyed areas.

Yam Pests and Disease Management Practices

Most of the farmers interviewed (39.5%) believed that using healthy yam tubers was the most widely used means to manage pests and diseases. Most of the farmers (74.9%) who used healthy tubers to manage the spread of yam pests and diseases were >50 years old. Approximately 40.8% of Wolaita farmers used healthy tubers, while 33.8% and 35.3% preferred pulling diseased plants as the most effective means of yam pests and disease management, respectively. A comparably higher percentage (36.2%) of formally educated farmers prioritized the use of healthy tubers, while not formally educated farmers preferred the use of manure and ashes (31.5%) as a worthwhile method for the management of yam pests and diseases. Only 3.5% of the farmers responded that they did not know how to handle pests and diseases. Therefore, they never used any method

(Table 8). The pest status of the yam and the disease management methods were significantly different according to age, education, and study zone (Table 3).

Discussion

Assessing and documenting farmers' knowledge of yam pests and diseases is important for developing effective and efficient management tools. Respondents from different backgrounds were included in the study. Most of the farmers interviewed had completed some level of formal education. Hence, they have a basic understanding of yam cultivation, pests and diseases, and management practices. Formal education, age, and experience of yam cultivation have a positive impact on farmers' perceptions (Frimpong et al. 2021). Most of the farmers interviewed said they had been growing yam for more than 7 years. Farmer knowledge is a starting point for investigating plant disease surveys and could be a good source of information for yam research and development activities (Mendesil et al. 2016, Penet et al. 2016).

The higher level of education was positively and significantly related to the preference of farmers for yam species. The most commonly cultivated yam species (farmer-preferred cultivars) are *D. rotundata* and *D. alata*. However, the production of metric yams decreased in study areas year after year. Farmers grow yam on very small hectares of land, with an average of 0.079 ha, and the average annual production (kg/ha) is 2,036.35. Adigoun-Akoteignon et al. (2020) reported that in Ethiopia, despite genetic diversity and accessible cropland, yam production has fallen from 200,000 annual productions in 1993 to 45,000 tons in 2020. Furthermore, the FAO (2021) reported that yam production in Ethiopia tended to decline between 2002 and 2021. In recent years, the production of yam fluctuated substantially, ending with a significant decline in 2022 (FAOSTAT 2022). Recent studies have shown that the virus (yam mosaic virus, genus *Potyvirus*, and family *Potyviridae*) is the most prevalent (28.5%) viral pathogen that widely infects yam in major growing areas of southern Ethiopia (Gogile et al. 2024a). Further study by the authors discovered novel potyviruses (Ethiopian yam virus-EYV) and novel criniviruses (YV-1) in the country (Gogile et al. 2024b) that might contribute to the decline in production of yam. Pests can also harm the yam tubers by declining their dry substance content, hence decreasing sprouting capability and diminishing quality by rendering them unmarketable (Andres et al. 2017). The low (less than 1:10) multiplication ratio of tubers and poor farm

Table 8. Respondents ratio of yam pests and diseases management practices used by farmers in southern Ethiopia

Variable (<i>n</i> = 342) Questionnaires	Overall no (%)	Respondents proportion (%) in different profiles														
		Sex		Age (years)				Education				Zones				
		M	F	18–29	30–49	50–69	>70	NFE	1'edu	2'edu	DW	GM	GF	KT	WL	
Yam pests and disease management methods mostly used																
Use of healthy tuber	135 (39.5)	32.1	26.5	26.7	26.0	40.5	44.4	26.2	32.7	36.2	23.5	30.2	19.1	8.8	40.8	
Crop rotation	59 (17.3)	17.2	14.7	11.1	21.4	14.9	3.7	19.5	13.5	20.6	13.7	16.3	16.2	14.7	21.4	
Disinfecting plantation by chemicals	30 (8.8)	16.8	19.1	24.4	15.8	9.5	33.3	7.4	26.9	15.6	23.5	15.1	16.2	32.4	11.7	
Pulling out the diseased plants	82 (24.0)	24.8	23.5	35.6	21.9	28.4	11.1	13.4	17.3	16.3	27.5	24.4	33.8	35.3	21.4	
Use of manures and ashes	24 (7.0)	7.7	4.4	0.0	10.2	5.4	7.4	31.5	3.8	7.1	7.8	8.1	10.3	5.9	3.9	
None	12 (3.5)	1.5	11.8	2.2	4.6	1.4	0.0	2.0	5.8	4.3	3.9	5.8	4.4	2.9	1.0	

NFE, not formally educated; 1'edu, primary education; 2'edu, secondary education or above; DW, Dawuro; GM, Gamo; GF, Gofa; KT, Kembata-Tembaro; WL, Wolaita.

practices during harvesting, transportation from the farms, and tuber losses during storage are supporting reasons for the decline in the production of yam (IITA 2015). Furthermore, the declining soil organization and fertility linked with shortening uncultivated periods have been responsible for declining yam production in potentially growing regions like sub-Saharan Africa (IITA 2009, 2015). These impediments challenge food security and farmers' ability to generate sustainable incomes in developing countries like Ethiopia.

Most of the farmers interviewed (43.3%) reported pests and diseases as major constraints to yam production. This was confirmed by field observation during the survey period. According to the farmers' responses, pests and diseases can infect yam at all stages of growth, although farmers' perceptions of these pests and diseases vary. This finding is consistent with the findings of scientific studies reporting that pests can significantly damage yams at all stages, from seedling to maturity and harvesting (FAO 2017, Tamiru et al. 2017).

Formally educated farmers could better identify and describe yam pests and diseases and susceptible yam species than those not formally educated once. This is directly related to disease identification and management practices because education can improve farmers' ability to receive, process, and understand the information that helps them make better decisions (Khan and Damalas 2015, Kindness et al. 2000).

Dioscorea rotundata (locally *Hatiya*) is the most economically important species due to its early maturity, high market value, and sweetness, and it is associated with the highest levels of pests and disease symptoms. Although little data were collected during this study to quantify the associated economic losses caused by pests and diseases in yam plants, other surveys have indicated that the income loss could range from 25% to 90% (Iorzu et al. 2020, Ntui et al. 2021). Pests (aphids, mealybugs, and signs of pathogens) and symptoms similar to bacterial and viral diseases were commonly observed in the yam fields during the survey. Nematodes have an adverse effect on the market value of yam tubers (Kindness et al. 2000). Bacteria, viruses, and nematodes were reported to be the most significant challenges associated with yam production (IITA 2009, Dutta 2015). The shortage of healthy planting material and rapidly changing climate conditions were additional constraints on yam production in the study areas (Ndambiri et al. 2015).

Farmers' perceptions offer useful information on yam cultivation practices, the distribution of yam pests and diseases, and management practices. Comparably, a higher number of the farmers interviewed (39.5%) believed that using healthy yam tubers was the most widely used means to manage pests and diseases. However, when seed tubers are too small or too large to be used as planting material, they use tubers from plants with foliar disease symptoms (Munyuli et al. 2017).

Farmers also use manure and ashes as natural fertilizer as well as a pests and diseases control strategy. This type of pest and disease management method is safer than the direct use of pesticides (Ntui et al. 2021). In general, most farmers use healthy yam tubers that were saved from the previous season or purchased from a local market, although they cannot be sure that the healthy tubers were healthy or infected. This indicates that farmers are planting tubers at a potential risk of pests and diseases because healthy-appearing tubers could be a source of a variety of diseases (Penet et al. 2016).

Farmers' knowledge of managing yam pests and diseases could be a starting point for further research. The findings can also help guide policymakers. The ability of farmers to identify and manage diseases and pests effectively is strongly influenced by their expertise. The acreage allocated for yam cultivation was low and the yam production had decreased in the areas surveyed. It was observed that

farmers are looking for yam-resistant species to increase yam production for use in the home and income generation. Laboratory-based diagnosis of yam pests and diseases and dissemination of true disease-free planting materials are needed to support farmer practices.

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Author contributions

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Ethical approval

Before undergoing a survey about the farmers' knowledge, they were informed of the purpose of the research and its benefits, clearly underlining that no commercial interest would be attached to it. A verbal agreement was obtained from the authorities of the local communities prior to administering the interview.

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Data availability

All data collected for this study were analyzed, interpreted, and included in this manuscript, but other data sets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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