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Research Article

Assessment of Onion Bulb and Seed Production Potentials and Challenges in Gebiresu Zone, Afar National Regional State, Ethiopia: Survey Findings

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Abstracts

This study, conducted in 2024, evaluates onion production practices, identifies key challenges, and explores potential improvements across four districts: Amibara, Gewane, Haruka, and Gelealo in the Middle Awash region of Ethiopia. The research focuses on current agricultural practices, the effectiveness of existing methods, and the socio-economic factors influencing onion farming. Each district exhibited distinct variations in these practices. Amibara showed relatively better adoption of recommended practices, particularly in irrigation and balanced fertilizer use. However, pest pressures, notably from Thrips and Stemphylium leaf blight, significantly affected yields. This district's reliance on chemical pesticides without integrated pest management (IPM) strategies poses long-term risks for soil health and pesticide resistance. Gewane and Haruka faced pronounced challenges related to water availability, leading to inconsistent irrigation practices. Gewane, with the lowest irrigation frequencies, showed reduced yields due to suboptimal water management. In both districts, pest infestations further exacerbated yield losses. This highlights the need for improved irrigation infrastructure and pest control strategies. In Gelealo, while fertilizer use was widespread, inconsistencies in application rates and a lack of IPM strategies led to lower yields. The district's reliance on local brokers for market access constrained economic outcomes. Additionally, like other districts, Gelealo lacked access to certified seeds, further limiting productivity. Pest and disease pressures were pervasive across all districts, particularly in Haruka and Amibara, where pest-related crop damage was highest. Moreover, the lack of post-harvest infrastructure and market access challenges, particularly in Gewane and Gelealo, reduced onion profitability. Overall, the findings underscore the critical need for improvements in irrigation, fertilization practices, pest control strategies, and market systems. District-specific interventions, such as promoting IPM, improving access to certified seeds, and enhancing market linkages, are essential to significantly improve onion yield, post-harvest quality, and economic returns in the Middle Awash region.

Keywords

Input Constraints, Disease and Insect Infestation, Market Access, Agro-pastoralists, Irrigation Practices, Soils Alinity

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1. Introductions

Onion (Allium cepa L.) is one of the most widely cultivated horticultural crops globally, contributing significantly to food security, income generation, and agricultural livelihoods. With a global production exceeding 100 million metric tons annually, onions play a vital role in human nutrition, offering essential vitamins, minerals, and bioactive compounds [1]. As a staple crop, onions are consumed worldwide and serve as a crucial ingredient in diverse culinary traditions. The versatility of onions, coupled with their long shelf life and robust market demand, positions them as a valuable commodity in both fresh and processed forms. Furthermore, onion seed production, a key segment of global agribusiness, ensures the sustainability of future onion cultivation [2].

On a global scale, onion production has been driven by the adaptability of the crop to a wide range of environmental conditions. Major onion-producing countries such as China, India, the United States, and Egypt together account for a significant proportion of the world's onion output [3]. Advances in technology, improved cultivation practices, and the development of high-yielding varieties have fueled the expansion of onion production worldwide [4]. However, despite these advancements, onion producers continue to face persistent challenges, including water scarcity, pest infestations, and post-harvest losses, particularly in developing countries.

In Africa, Ethiopia has emerged as a key player in onion production, contributing substantially to the continent's horticultural sector. Over the past few decades, onion cultivation in Ethiopia has seen remarkable growth, driven by rising domestic demand and the potential for export [5]. The country's diverse agro-climatic zones offer favorable conditions for onion farming, especially in regions where irrigation is accessible. The Middle Awash region, located in the Afar National Regional State, is particularly suitable for onion cultivation due to the availability of large-scale irrigation systems fed by the Awash River [6]. These irrigation networks are critical for sustaining agriculture in arid and semi-arid regions like Afar, where rainfall is irregular and insufficient for rain-fed agriculture.

The Gebiresu Zone, part of the Middle Awash region in Afar, is one of Ethiopia's key onion-producing areas. The region's strategic location, fertile soils, and access to the Awash River for irrigation have made onion cultivation a dominant agricultural activity. Both smallholder producers and commercial producers in the zone benefit from the region's well-established irrigation infrastructure, which allows for year-round onion production [7]. In addition to local consumption, onions from this region are supplied to major markets, including Addis Ababa and other urban centers. Moreover, the agro-pastoralist communities in Gebiresu Zone have increasingly incorporated onion farming into their livelihoods, balancing it with traditional livestock rearing to diversify their income sources [8].

Onion seed production is a crucial aspect of ensuring the sustainability and productivity of onion farming. Globally, countries such as India, the United States, and the Netherlands lead in advanced onion seed production, driven by breeding programs, research, and commercial seed enterprises [9]. High-quality seeds are critical for successful onion farming, as they determine factors like germination rates, disease resistance, and yield potential.

However, in Ethiopia, onion seed production remains underdeveloped. Many producers rely on informal seed systems, where seeds of variable quality are used, often resulting in suboptimal crop performance. Certified seed availability is limited, and challenges such as poor seed quality and market inefficiencies further constrain the development of formal seed systems [10]. In the Middle Awash region, including Gebiresu Zone, environmental stressors like high temperatures, water scarcity, and soil salinity complicate seed production [11]. These constraints lead producers to depend on locally produced or imported seeds, which may not be well-suited to the region's specific conditions [12].

Despite the favorable agro-climatic conditions and potential for expansion, onion production in Ethiopia faces numerous challenges. Water scarcity is one of the most critical limitations, particularly in arid regions such as Afar, where irrigation is essential for crop survival [13]. The dependency on irrigation systems means that fluctuations in water availability, inefficient water management practices, and competition for water resources can severely affect onion yields. Additionally, pest and disease outbreaks, such as thrips and bulb rot, are recurrent problems, exacerbated by limited access to effective pest control measures and agricultural inputs [14].

Moreover, the lack of access to high-quality onion seeds is another major challenge. In regions like Afar, many producers rely on informal seed systems, which often deliver seeds of inconsistent quality and genetic purity [15]. This reliance on substandard seeds reduces productivity and makes crops more vulnerable to environmental stresses and disease pressures. Compounding these issues are market inefficiencies, including price fluctuations and poor post-harvest handling, which prevent producers from maximizing their production potential [16].

In generals, while onion bulb and seed production in the Gebiresu Zone of Afar National Regional State holds significant potential, several critical challenges need to be addressed to optimize productivity and ensure the sustainability of onion farming in the region. This study aims to assess these potentials and challenges in detail, providing valuable insights for future interventions and policy-making to enhance agricultural productivity in the region.

2. Research Design and Population of the Study

2.1. Description of the Study Area

The survey was conducted during the 2023/24 cropping season in three districts: Amibara, Gewane, and Gelealo within Zone-3 of the Afar National Regional State, Ethiopia. Zone-3 is situated approximately 280 kilometers northeast of Addis Ababa and falls within the arid and semi-arid agro-ecological zones. The region is predominantly characterized by high temperatures, low and erratic rainfall, and prolonged dry seasons, which pose substantial challenges to agricultural productivity. The altitude of the study area averages 740 meters above sea level, with mean annual temperatures reaching 34℃. Rainfall in the region is sparse, averaging around 560 mm per year, while the evapotranspiration rate is notably high at approximately 2600 mm, further intensifying water scarcity.

Despite these climatic challenges, the area holds significant agricultural potential due to the presence of the Awash River, which supports extensive irrigation schemes. The Awash River is a critical water source, enabling year-round cultivation, particularly in the fertile floodplains. This irrigated agricultural system makes the region a key production area for horticultural crops such as onions, tomatoes, and watermelons, which dominate the cropping landscape and serve as the primary sources of income for local agro-pastoralists. The large-scale cultivation of these crops contributes substantially to both local food security and the regional economy, with horticulture playing a central role in agricultural activities.

Amibara, Gewane, and Gelealo districts exhibit similar agro-ecological conditions but vary slightly in terms of soil composition and access to irrigation infrastructure. Soils in these districts are primarily alluvial, benefiting from nutrient deposition from the river, but they also experience issues related to salinity and degradation due to over-irrigation and unsustainable farming practices. The region's agriculture relies heavily on the efficient management of water resources, as the hot and dry climate, coupled with unpredictable rainfall, exacerbates water scarcity and limits the productivity of rain-fed crops.

The study area is also home to a predominantly agro-pastoralist community, where livestock farming is integrated with crop production. While horticultural crops dominate the irrigated fields, livestock rearing remains an essential livelihood activity, with cattle, camels, and goats being common. However, the increasing pressures of climate change and water shortages necessitate the development of sustainable farming practices, particularly those that focus on optimizing irrigation, conserving soil moisture, and adopting heat-tolerant crop varieties.

2.2. Sampling Method

Target Population: The survey targeted agro-pastoralist households and onion producers in Amibara, Gewane, and Gelealo districts, Zone-3 of Afar National Regional State. These households rely on onion farming, either through direct cultivation or involvement in the onion seed production value chain.

Sample Size: A total of 200 households were surveyed, with 50 households randomly selected from each district to ensure adequate representation of onion farming practices and seed-related challenges.

Sampling Technique: A stratified random sampling method was used, stratifying households by socio-economic status (income, land ownership, and production scale) to capture the perspectives of both small-scale and large-scale producers. This approach ensured the sample was representative of the broader population.

2.3. Data Collection Procedures

Survey Tools: Enumerators received training on administering structured questionnaires, focusing on accurate data collection techniques. The structured interviews covered onion seed challenges, including market availability, seed quality, germination issues, and pest resistance.

Field Observation: In addition to interviews, enumerators conducted field visits to observe onion cultivation techniques, seed germination, pest outbreaks, irrigation methods, and water access challenges.

Ethical Considerations: Enumerators were trained on securing informed consent, maintaining confidentiality, and respecting cultural norms to ensure ethical data collection.

Engagement Strategies: The training emphasized rapport-building techniques, active listening, and respectful communication, along with strategies to minimize disruption during field observations.

2.4. Data Analysis

2.4.1. Quantitative Data Analysis

Data collected from structured interviews were digitized and analyzed using statistical software such as SPSS. Descriptive statistics, including means, frequencies, and percentages, were utilized to summarize key aspects such as the availability of seeds, their affordability, and usage patterns in onion cultivation. Additionally, cross-tabulation were employed to investigate the relationships between various socio-economic factors, such as household income and farm size, and seed access. This analysis aims to identify any inequalities in seed access or quality among different demographic groups.

2.4.2. Qualitative Data Analysis

Data gathered through focus group discussions (FGDs) and field observations were analyzed using thematic coding. This process was involved identifying and organizing common themes related to challenges in seed access, entrepreneurship in onion farming, and market opportunities into thematic categories. The qualitative insights gained will serve to complement the quantitative findings by providing essential context and elucidating the underlying causes of seed-related challenges faced by the agro-pastoralist community.

3. Results and Discussion

3.1. Demographic Characteristics

The demographic profile of onion producers in the Middle Awash area, covering the districts of Amibara, Gelealo, Haruka, and Gewane in the Middle Awash area, particularly regarding gender, education level, family size, and age of respondents (N=200), were presented in Table 1.

1) Gender of Household

The survey results indicate that the majority of households in all four districts are male-headed. Amibara shows 78% male-headed households, while Gelealo, Haruka, and Gewane have 92%, 88%, and 100%, respectively. Across all districts, male-headed households represent 89.5% of the total (179 out of 200 households). This gender imbalance is not uncommon in agro-pastoral communities where male members traditionally dominate decision-making in agricultural production (FAO, 2017). Female-headed households are most present in Amibara (22%) and least in Gewane (0%). Female-headed households, although fewer, may face more challenges in terms of access to resources, land, and extension services, which could influence their productivity and adoption of new technologies [17, 18].

2) Education

Education levels vary significantly across districts. Gewane has the highest percentage of illiterate respondents (32%), followed by Amibara (28%), Haruka (24%), and Gelealo (22%). Overall, 26.5% of respondents are illiterate. On the other hand, respondents who have completed education above high school represent 24.5% of the total population, with the highest concentration in Gelealo (32%) and Haruka (30%). Research has consistently shown that producer with higher levels of education is more likely to adopt improved agricultural technologies, leading to higher productivity and incomes [19]. The relatively high level of education in Gewane may position this district as a more favorable area for introducing advanced agricultural innovations.

3) Family Size

The majority of households across the districts have family sizes of 1 to 3 members, representing 73.5% of the total respondents. Gelealo (84%) and Haruka (76%) have the highest percentages of smaller households, while Gewane (72%) and Amibara (62%) also follow this trend. Households with more than 6 members are relatively rare, especially in Gewane (6%) and Haruka (8%), compared to Amibara (28%). Conversely, larger families, although fewer in number, might provide more labor for farming activities, allowing households to engage in more extensive production [20]. The relatively higher number of smaller families in this study could indicate a need for labor-saving technologies or improved mechanization to offset labor constraints.

4) Age of Respondents

The age distribution shows that the majority of respondents (71%) fall within the 25-40 age range, indicating that the onion production sector in the Middle Awash region is driven by relatively young producers. Haruka has the highest proportion of respondents aged 25-40 (82%), followed by Gelealo (76%) and Amibara (62%). This demographic points to a vibrant and youthful workforce engaged in farming activities. On the other hand, a smaller percentage of respondents are aged 41-60 (19.5%) and 61-80 (9.5%), which suggests that the older generation may be gradually withdrawing from active farming roles. Younger producers are generally more open to change and risk-taking in farming compared to older producer who may be more risk-averse [21]. However, older respondents, particularly those aged above 60, may possess valuable traditional knowledge, which could be beneficial in integrating modern and traditional agricultural practices.

Table 1. *Demographic profile.*

Descriptions	Districts								Total (N=200)	
	Amibara (N=50)		Gelealo (N=50)		Haruka (N=50)		Gewane (N=50)			
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Gender of Household										
Male	39	78	46	92	44	88	50	100	179	89.5
Female	11	22	4	8	6	12	0	0	21	10.5

Descriptions	Districts								Total (N=200)	
	Amibara (N=50)		Gelealo (N=50)		Haruka (N=50)		Gewane (N=50)			
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Education										
Illiterate	14	28	11	22	12	24	16	32	53	26.5
Read and write	8	16	9	18	6	12	4	8	27	13.5
Elementary	9	18	8	16	3	6	10	20	30	15
High school	9	18	6	12	14	28	12	24	41	20.5
Above 12	10	20	16	32	15	30	8	16	49	24.5
Family Size										
1 to 3	31	62	42	84	38	76	36	72	147	73.5
4 to 6	5	10	4	8	8	16	11	22	28	14
Above 6	14	28	4	8	4	8	3	6	25	12.5
Age of Respondent										
25 to 40	31	62	38	76	41	82	32	64	142	71
41 to 60	11	22	8	16	5	10	15	30	39	19.5
61 to 80	8	16	4	8	4	8	3	6	19	9.5

3.2. Land Holding and Experience in Onion Seed Production

The data in Table 2 provides a detailed breakdown of onion seed farming experience across the districts of Amibara, Gelealo, Haruka, and Gewane in Gebiresu Zone. This analysis highlights key differences in landholding, land allocation for onion bulb production, and the experience levels of producers in onion seed and bulb production across these districts.

1) Total Land Holding (ha)

Producers in the surveyed districts exhibited a variation in total landholdings, reflecting the overall availability of land for agricultural activities. In Amibara, 62% of the producers held land greater than 4 hectares, a proportion matched by 64% of producers in both Gelealo and Gewane. However, Haruka had the highest percentage of producers (72%) with more than 4 hectares of land. This pattern suggests that, across all districts, larger landholdings are predominant, which aligns with the large-scale agricultural practices typically observed in the Awash Valley, where large irrigation schemes exist [22].

In contrast, smallholders with land holdings of 1 to 2 hectares are relatively less common, representing only 12% of the total respondents. This suggests that while some small-scale farming is practiced, most producers operate on larger plots, indicating their potential to scale production if resources and market conditions allow [23].

2) Land for Onion Bulb Production

The allocation of land for onion bulb production varies significantly across the districts. The majority of producers in all districts, especially Gewane (62%), allocate more than 1 hectare of land for onion production. The district with the smallest portion of land dedicated to onion bulb production is Gelealo, with only 58% allocating more than 1 hectare.

The higher land allocation for onion bulb production in Gewane may be attributed to the district's proximity to reliable water sources for irrigation, which is essential for successful onion cultivation [24]. By contrast, the slightly lower figures in Gelealo may reflect either constraints in irrigation infrastructure or competing crops vying for available farmland.

3) Experience in Onion Seed Production

The survey revealed that the overwhelming majority of producers (89.5%) in all districts have no experience in onion seed production. This lack of experience is uniform across the districts, with no respondents reporting more than five years of experience in this area. This indicates a critical gap in knowledge and practice, which could be a major limitation for seed self-sufficiency and a reliance on external seed sources, which can be costly and unpredictable [25].

This lack of experience also suggests that efforts to introduce seed production technologies and training have not yet reached a significant number of producers in these areas, possibly due to logistical challenges, weak extension services, or limited market incentives for seed production [26].

Therefore, there is a considerable need for capacity-building initiatives, extension services, and technology dissemination focused on seed production.

4) Experience in Onion Bulb Production

When it comes to onion bulb production, the majority of producers in the districts of Amibara (52%), Gelealo (48%), and Haruka (40%) reported having between 10 and 20 years of experience, indicating a well-established tradition of onion cultivation. Gewane had an even higher percentage of producers (66%) within this range, which could be linked to the district's greater access to irrigation and its longer history of agricultural commercialization [27].

This level of experience shows that onion bulb production has been a longstanding activity for these producers, offering them valuable expertise in cultivation practices. However, it also underscores the persistent gap between bulb production and seed production capabilities. The survey results highlight a clear trend across all districts: while onion bulb production is well-established and practiced over significant land areas, onion seed production remains virtually absent. This lack of seed production experience across the board suggests that efforts to improve seed self-sufficiency must be a priority, especially since many producers rely on external seed sources, which introduces vulnerabilities such as seed shortages, higher input costs, and dependence on market fluctuations [28].

Moreover, the allocation of large areas for onion production demonstrates the importance of the crop for local livelihoods, though the differences in landholdings and access to resources among the districts suggest that targeted interventions will be necessary to address specific constraints in each area [29].

Table 2. *Onion seed farming experience.*

Descriptions	Districts								Total (N=200)	
	Amibara (N=50)		Gelealo (N=50)		Haruka (N=50)		Gewane (N=50)			
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Total land holding (ha)										
1 to 2	8	16	6	12	4	8	6	12	24	12
>2 to 4	11	22	12	24	10	20	12	24	45	22.5
>4	31	62	32	64	36	72	32	64	131	65.5
Land for onion bulb (ha)										
<0.25	0	0	1	2	0	0	0	0	1	0.5
0.25-0.5	4	8	2	4	6	12	4	8	16	8
>0.5-0.75	9	18	8	16	7	14	6	12	30	15
>0.75-1	16	32	10	20	12	24	9	18	47	23.5
>1	21	42	29	58	25	50	31	62	106	53
Experience of onion seed production (year)										
0	46	92	43	86	44	88	46	92	179	89.5
1 to 5	4	8	7	14	6	12	4	8	21	10.5
6 to 10	0	0	0	0	0	0	0	0	0	0
11 to 15	0	0	0	0	0	0	0	0	0	0
> 15	0	0	0	0	0	0	0	0	0	0
Experience of onion bulb production (year)										
0	4	8	7	14	6	12	4	8	21	10.5
<10	11	22	8	16	16	32	9	18	44	22
10 to 20	26	52	24	48	20	40	33	66	103	51.5
20 to 30	9	18	11	22	8	16	4	8	32	16
>30	0	0	0	0	0	0	0	0	0	0

3.3. Onion Seed Acquisition: Sources and Procurement Locations

Table 3 presents the survey results regarding knowledge and skills in onion seed acquisition across four districts in Gebiresu Zone: Amibara, Gelealo, Haruka, and Gewane. This analysis compares how producers acquire seeds, their criteria for seed selection, and the overall implications of their knowledge on seed acquisition practices.

1) Seed Sources

The table reveals that the majority of producers across all districts rely on purchasing seeds from markets. In Gelealo, 82% of the respondents purchase their seeds from the market, followed closely by Haruka at 78%, Gewane at 72%, and Amibara at 68%. Overall, 75% of the producers across the four districts depend on markets for their seed supply. This reliance on market-based seed acquisition reflects the limited capacity for seed self-production, a pattern that may be driven by the lack of knowledge or resources to produce onion seeds locally [30]. It also suggests a vulnerability in the seed system, as market fluctuations and the availability of quality seeds could significantly affect producers' access to seeds [31].

In contrast, purchasing seeds from cooperatives is relatively uncommon, with only 10.5% of the total respondents using this source. Amibara had the highest percentage of cooperative-based seed acquisition at 16%, while Haruka had the lowest at just 2%. The low level of seed purchases from cooperatives may indicate either limited access to cooperative services in these areas or a lack of trust in the quality of seeds provided by these entities. This is a key issue, as cooperatives are generally considered a reliable source for quality-controlled seeds in many agricultural systems [29].

Additionally, some producers, though few in number, obtain seeds from research centers, with Haruka showing the highest engagement at 18%, followed by Amibara at 16%. Research centers play a vital role in introducing improved seed varieties, and the moderate engagement of some producers with these institutions suggests a degree of awareness of the potential benefits of using scientifically developed seeds. However, the low overall percentage (12.5%) across all districts indicates that there is still significant room for improvement in linking producers with research institutions for enhanced seed access [32].

The use of NGO-supplied seeds is minimal, with only 2% of the respondents across all districts obtaining seeds through this channel. This reflects a limited presence of NGO interventions focused on seed supply in the region, or it may suggest that such programs are not widely reaching onion producers in Gebiresu Zone [33].

2) Seed Source Selection Criteria

Producers across all four districts overwhelmingly base their seed selection on availability, with 77% of the total respondents citing this as the primary criterion. This trend is consistent across districts, with Haruka leading at 84%, followed by Gelealo at 80% and both Amibara and Gewane at 72%. This indicates that producers prioritize ease of access over other potential factors, such as seed quality or yield potential. This could be a result of limited market options or a lack of awareness of the benefits of selecting seeds based on other criteria [34].

Cost is the second most important factor, particularly in Amibara and Gewane where 20% of the producers consider it a significant factor in seed selection. This reflects the economic constraints faced by producers in these districts, where affordability often takes precedence over other characteristics like quality. Gelealo and Haruka report lower percentages (16% and 4%, respectively) of producers considering cost as a factor, which might suggest slightly better economic conditions or different market dynamics in these districts.

Interestingly, none of the respondents across all districts selected seeds based on criteria such as yield potential, adaptability, shelf life, or seed quality. This is a concerning trend, as it highlights a significant gap in producers' knowledge regarding the importance of using high-quality seeds for improving productivity. High-quality seeds can lead to better crop performance and yield, as well as resistance to diseases and pests [35]. The absence of these criteria from the decision-making process suggests that producers may not fully understand the long-term benefits of improved seed varieties, or that they simply do not have access to such seeds [36].

Table 3. *Knowledge and skill in onion seed acquisition.*

Descriptions	Districts								Total (N=200)	
	Amibara (N=50)		Gelealo (N=50)		Haruka (N=50)		Gewane (N=50)			
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Seed sources										
Own seed	0	0	0	0	0	0	0	0	0	0
Purchase from agro-pastoralist	0	0	0	0	0	0	0	0	0	0

Descriptions	Districts Amibara (N=50)		Gelealo (N=50)		Haruka (N=50)		Gewane (N=50)		Total (N=200)	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Purchas from cooperatives	8	16	5	10	1	2	7	14	21	10.5
Purchase from market	34	68	41	82	39	78	36	72	150	75
From research center	8	16	2	4	9	18	6	12	25	12.5
NGOS	0	0	2	4	1	2	1	2	4	2
Seed source selection criteria										
Availability	36	72	40	80	42	84	36	72	154	77
Better seed quality	4	8	2	4	6	12	4	8	16	8
To replace old variety	0	0	0	0	0	0	0	0	0	0
Based on cost	10	20	8	16	2	4	10	20	30	15
Adaptability	0	0	0	0	0	0	0	0	0	0
Seed Quality	0	0	0	0	0	0	0	0	0	0
Yield Potential	0	0	0	0	0	0	0	0	0	0
Shelf Life	0	0	0	0	0	0	0	0	0	0

3.4. Agronomic Practices Used for Onion Production

3.4.1. Site Selection Criteria

Table 4 presents the survey results related to site selection parameters for onion seed farming across four districts in Gebiresu Zone: Amibara, Gelealo, Haruka, and Gewane. The table focuses on four key factors that influence producers' decisions when selecting a site for onion farming: soil fertility, drainage, water availability, and previous crop history.

1) Soil Fertility

Soil fertility was identified as an important site selection parameter by 34.5% of the total respondents. Producers in Haruka showed the highest concern for soil fertility, with 46% prioritizing it as a key factor. This is likely due to the recognition that fertile soils enhance crop productivity and reduce the need for external inputs like fertilizers, which can be costly (Bekele et al., 2017). In Amibara, 40% of the respondents emphasized soil fertility, followed by Gewane at 32% and Gelealo at 20%. The relatively low concern for soil fertility in Gelealo might reflect the district's perceived access to fertile land or lower awareness of the long-term benefits of soil fertility management. These disparities suggest that knowledge and awareness of soil fertility's importance in ensuring high yields vary among districts, and targeted agricultural extension services could help bridge this gap [37].

2) Well-Drained Soil

The importance of well-drained soil was recognized by 20.5% of respondents across the four districts. Gewane had the highest proportion of producers considering this factor at 28%, followed by Haruka at 18%, Amibara at 20%, and Gelealo at 16%. Well-drained soils are crucial for preventing waterlogging, which can damage crops, especially onions that are sensitive to excessive moisture (Amsalu & Alemu, 2020). The relatively lower emphasis on drainage across all districts indicates a potential area for improvement in educating producers about proper site selection to avoid water-related issues. Gewane's higher focus on drainage could stem from previous experiences with waterlogging, prompting producers to prioritize this parameter.

Studies have shown that salinity tends to develop in areas where irrigation is prevalent but drainage is insufficient. This is especially true in semi-arid and arid regions where evaporation rates are high, such as the districts in the Gebiresu Zone. According to [38], proper soil drainage systems are essential to prevent the accumulation of salts that could otherwise lead to the degradation of soil quality. The emphasis on well-drained soil in Gewane may reflect past challenges with both waterlogging and salinity, driving producers to prioritize drainage as a solution.

3) Water Availability

Water availability was the most critical site selection parameter overall, with 37% of the respondents citing it as a key factor. Gelealo showed the highest concern for water availability, with 60% of producers prioritizing this factor, which likely reflects the district's semi-arid climate and dependence on irrigation for farming (Fekadu et al., 2019). Amibara and Gewane also demonstrated significant concern for water availability, with 32% of producers in each district focusing on this factor. In contrast, Haruka had the lowest emphasis on water availability, with only 24% of the respondents mentioning it, despite its reliance on irrigation systems. The differences across districts suggest that some regions, particularly Gelealo, are more aware of the risks posed by water scarcity, a crucial issue in onion production [39].

4) Previous Crop

The parameter of previous crop was the least considered factor across all districts, with only 8% of the total respondents citing it as a site selection criterion. Haruka had the highest proportion of producers taking previous crops into account (12%), followed by Amibara and Gewane at 8%, and Gelealo at 4%. Crop rotation and previous crop history are important for soil health and disease management, but the low emphasis on this factor suggests a lack of knowledge among producers regarding the benefits of crop rotation for pest and disease control [40]. This highlights the need for improved agricultural education on sustainable farming practices to enhance onion production efficiency and reduce soil degradation.

Table 4. *site selection parameters.*

Descriptions	Districts								Total (N=200)	
	Amibara (N=50)		Gelealo (N=50)		Haruka (N=50)		Gewane (N=50)			
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Soil fertility	20	40	10	20	23	46	16	32	69	34.5
Well-drained	10	20	8	16	9	18	14	28	41	20.5
Water Availability	16	32	30	60	12	24	16	32	74	37
Previous crop	4	8	2	4	6	12	4	8	16	8

3.4.2. Variety Selection and Its Criteria

The survey results on variety preferences and selection criteria for onion cultivation across the four districts: Amibara, Gelealo, Haruka, and Gewane reveal key insights into the producers' preferences and considerations when choosing onion varieties. By analyzing and comparing the data from each district, we can identify patterns and potential areas for improvement in variety selection and crop management.

1) Variety Preferences

Across the four districts, a significant portion of the producers (51.5%) reported using unknown varieties of onions, with the highest percentages in Gelealo and Gewane (60% each). In Haruka, 46% of respondents reported using unknown varieties, while Amibara had the lowest at 40%. The widespread use of unknown varieties could indicate a lack of access to improved seeds or inadequate extension services that provide information about recommended onion varieties. Producers might be relying on local seed sources or traditional varieties, which may not always be optimized for yield, pest resistance, or market preferences [41].

The Bombe Red variety was the second most popular, used by 36.5% of the respondents overall. Amibara had the highest proportion of producers growing Bombe Red (50%), while Gewane had the lowest (28%). This suggests that in some districts, there is a stronger awareness or preference for this specific variety, possibly due to its known performance in terms of yield or market demand. Bombe Red may have characteristics such as bulb color or size that align with consumer preferences, driving its popularity in some regions [42].

The Adama Red variety was the least preferred, with only 12% of respondents overall selecting it. Haruka had the highest proportion of producers using Adama Red (18%), while Gelealo had the lowest (8%). This lower adoption rate might be due to regional differences in soil conditions, water availability, or market demand, suggesting that Adama Red is either less suited to the growing conditions or less favored by local markets [43].

2) Selection Criteria

a) Bulb Yield

Across all districts, bulb yield was the most important selection criterion for producers, with 40.5% of respondents prioritizing this factor. Haruka had the highest proportion of producers focused on bulb yield (46%), followed by Gelealo (44%) and Amibara (40%). Gewane had the lowest percentage (32%), which could suggest that producers in this district may prioritize other factors over yield or may be facing constraints that limit the effectiveness of yield-improving practices. The focus on yield highlights the producers' need to maximize production, likely driven by both household food security and market opportunities [44].

b) Early Maturity

Early maturity was the second most common selection criterion, chosen by 20.5% of respondents overall. Gewane had the highest proportion of producers valuing early maturity (28%), likely due to the need to avoid the risks posed by climate variability or water shortages. Amibara and Haruka placed less emphasis on early maturity, with only 20% and 18% of producers selecting this criterion, respectively. Early-maturing varieties are particularly important in regions where water is scarce or where producers seek to minimize the risk of crop failure due to environmental stresses [45].

c) Disease/Insect Pest Tolerance

Interestingly, only 4.5% of producers overall considered disease and insect pest tolerance as a selection criterion, with Gewane having the highest proportion (8%) and Amibara not mentioning it at all. This low emphasis on pest and disease tolerance may suggest that producers are either unaware of the importance of selecting resistant varieties or that they are not experiencing significant pest and disease pressures. However, if pest and disease issues increase, it is likely that producers will need to reconsider this factor in their variety selection [46].

d) Bulb Size and Color

Bulb size was important for 19.5% of producers, with Gelealo (24%) and Amibara (20%) giving it the most attention. Similarly, bulb color was selected by 15% of respondents, with the highest proportion in Haruka (18%). These traits likely reflect market preferences, where consumers and traders may favor larger bulbs or specific colors for better prices [47]. The relatively lower emphasis on these traits compared to yield suggests that while market traits are important, yield optimization remains the primary focus for most producers.

The survey results suggest a significant reliance on unknown varieties, particularly in Gelealo and Gewane, which could limit producers' productivity and market potential. The lower use of improved varieties such as Bombe Red and Adama Red points to a need for better access to improved seed and producer education on the benefits of these varieties. Additionally, while bulb yield remains the top priority, the lack of emphasis on pest and disease tolerance could be a missed opportunity for improving onion productivity, especially as climate change and intensifying agriculture may increase the risk of pest outbreaks. Extension services should focus on promoting improved varieties that offer both high yields and resistance to pests and diseases [48].

Table 5. *Variety and Selection Criteria.*

Descriptions	Districts								Total (N=200)	
	Amibara (N=50)		Gelealo (N=50)		Haruka (N=50)		Gewane (N=50)			
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Variety preferences										
Unknown	20	40	30	60	23	46	30	60	103	51.5
Bombe Red	25	50	16	32	18	36	14	28	73	36.5
Adama Red	5	10	4	8	9	18	6	12	24	12
Selection Criteria										
Bulb yield	20	40	22	44	23	46	16	32	81	40.5
Early maturity	10	20	8	16	9	18	14	28	41	20.5
Disease/insect pest tolerance	0	0	2	4	3	6	4	8	9	4.5
Bulb size	10	20	12	24	6	12	11	22	39	19.5
Bulb color	10	20	6	12	9	18	5	10	30	15

3.4.3. Land Preparation Practices

The survey results on land preparation and spacing practices for onion cultivation across the four districts: Amibara, Gelealo, Haruka, and Gewane highlight the diversity in agricultural practices among producers. By analyzing the data from each district, we can better understand the prevailing techniques used in land preparation and spacing, and their potential impact on productivity. These differences also suggest areas for improvement and opportunities for introducing more efficient and effective practices in onion cultivation.

1) Land Preparation: Frequency of Ploughing

Only a small portion of producers (7.5%) reported ploughing their land once, with Haruka having the highest percentage (12%), followed by Gewane (8%), Gelealo (6%), and Amibara (4%). This low frequency of ploughing may suggest minimal land preparation in these areas, potentially affecting crop establishment and yields. Studies indicate that insufficient ploughing can lead to poor soil aeration and root development, thereby limiting crop productivity [49].

Two times ploughing was reported by 22% of respondents overall, with the highest proportion in Gewane (28%), followed by Haruka (24%), Amibara (20%), and Gelealo (16%). While this practice is more common than one-time ploughing, it may still be insufficient for optimum soil preparation, especially in areas with heavy or compacted soils where additional ploughing can enhance soil structure and moisture retention [50].

The majority of producers (58%) across all districts ploughed their land three times, making it the most common practice. Gelealo led with 70%, followed by Amibara (60%), Gewane (56%), and Haruka (46%). Three times ploughing is generally considered adequate for onion cultivation, as it helps break up the soil, improves drainage, and provides better conditions for seedling establishment [51]. The widespread adoption of this practice in Gelealo may reflect greater awareness of its benefits.

A smaller percentage of producers (9%) ploughed their land four times, with Amibara having the highest proportion (12%), while Gelealo and Haruka reported lower percentages (4% and 12%, respectively). Only 3.5% of respondents ploughed their land more than five times, with Haruka showing the highest rate (6%), while Gewane had none. Ploughing more than three times may be excessive in most cases, and it can lead to soil degradation or increased costs without necessarily improving yields [52].

2) Row Spacing

Only 16% of respondents used a 40 cm row spacing, with Gelealo (20%) having the highest percentage, followed by Haruka (18%), Amibara (14%), and Gewane (12%). Narrow row spacing can lead to overcrowding, which increases competition for nutrients, light, and water, ultimately reducing bulb size and yield [53].

The most commonly used row spacing was 50 cm, adopted by 57.5% of producers across all districts. Haruka had the highest proportion (64%), followed by Gelealo (50%), Gewane (56%), and Amibara (60%). This spacing is optimal for onion cultivation, as it allows sufficient room for bulb development and ensures better air circulation, which can reduce disease pressure [54]. 60 cm spacing was practiced by 20% of respondents, with Gelealo (26%) leading, followed by Gewane (24%), Amibara (18%), and Haruka (12%). Wider row spacing can benefit soil moisture conservation but may result in reduced planting density, leading to lower overall yields per hectare [24]. The least common row spacing was 70 cm, used by only 6.5% of producers, with Amibara (8%) and Gewane (8%) having the highest proportions. This spacing is typically too wide for onions, as it results in underutilized land and lower yields [55].

3) Spacing between Plants

A significant number of producers (40%) practiced a plant spacing of less than 5 cm, with the highest proportion in Gelealo (60%) and Amibara (52%). This tight spacing can lead to overcrowding, causing small bulb sizes due to competition for resources. Overcrowded planting is also associated with higher susceptibility to diseases [56].

5 cm spacing was adopted by 26.5% of respondents, with the highest adoption in Gelealo (20%) and Haruka (24%). This spacing is often recommended for onion production, as it allows for optimal bulb development while ensuring efficient land use. The relatively lower adoption in Amibara and Haruka suggests an area where extension services could improve producer practices (Alemayehu et al., 2019). 10 cm spacing was used by 16% of respondents overall, with the highest adoption in Haruka (18%) and Gelealo (16%). This wider spacing can lead to larger bulb sizes but may reduce overall yield per unit area if the spacing is too wide for optimal plant density [57]. Only 17.5% of producers reported using plant spacing of greater than 10 cm, with Amibara and Gewane having the highest adoption (6% each). This spacing is generally too wide for onion production, resulting in lower overall yields, although it can reduce competition and potentially increase individual bulb size [58].

The survey results show significant variation in land preparation and spacing practices across the four districts. Three times ploughing was the most common method of land preparation, particularly in Gelealo and Amibara, which aligns with recommended agricultural practices for onion cultivation. However, the use of one or two times ploughing in some districts suggests that more education is needed to promote optimal soil preparation techniques. In terms of spacing, 50 cm row spacing and 5 cm plant spacing were the most widely adopted practices, particularly in Haruka and Gelealo. These practices are consistent with recommendations for maximizing both yield and bulb quality. However, the prevalence of less than 5 cm plant spacing in Gelealo and Amibara suggests that some producers may not be fully aware of the negative impacts of overcrowding on bulb size and yield.

Table 6. *Land preparations and spacing.*

Descriptions	Districts								Total (N=200)	
	Amibara (N=50)		Gelealo (N=50)		Haruka (N=50)		Gewane (N=50)			
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Ploughing										
One times	2	4	3	6	6	12	4	8	15	7.5
Two times	10	20	8	16	12	24	14	28	44	22
Three times	30	60	35	70	23	46	28	56	116	58
Four times	6	12	2	4	6	12	4	8	18	9
> Five times	2	4	2	4	3	6	0	0	7	3.5
Spicing between rows (cm)										
40	7	14	10	20	9	18	6	12	32	16
50	30	60	25	50	32	64	28	56	115	57.5
60	9	18	13	26	6	12	12	24	40	20
70	4	8	2	4	3	6	4	8	13	6.5
Spacing between plants (cm)										
< 5	26	52	30	60	25	50	22	44	80	40
5	14	28	10	20	12	24	17	34	53	26.5
10	7	14	8	16	9	18	8	16	32	16
> 10	3	6	2	4	4	8	3	6	35	17.5

3.4.4. Nursery Managements and Translating

The survey results on nursery management and transplanting practices across the four districts: Amibara, Gelealo, Haruka, and Gewane reveal important insights into onion cultivation techniques. These findings highlight significant variation in seed rate, sowing method, sowing time, days spent in the nursery, and transplanting time. Understanding these practices is crucial for improving onion production in the region by optimizing the various stages of crop establishment. Here, we analyze and compare the results for each district and the overall findings, with relevant references.

1) Seed Rate (kg/ha)

A small portion of producers (6.5%) used a seed rate of 5 to 6 kg/ha, with Haruka having the highest proportion (12%), followed by Gewane (8%), Amibara (4%), and Gelealo (2%). This lower seed rate might indicate more careful seed management, but could also reflect a potential underutilization of land, as onion production often benefits from higher seed rates in certain environments [59].

Around 17.5% of producers used 6 to 10 kg/ha, with Gewane showing the highest adoption (28%), followed by Haruka (18%), Gelealo (16%), and Amibara (8%). This seed rate is considered moderate and may help balance seed costs with optimal plant density, promoting better bulb development [60].

The 11 to 15 kg/ha range was the most common seed rate used by 34.5% of producers. Gelealo had the highest proportion (42%), followed by Amibara (40%), Gewane (32%), and Haruka (24%). This seed rate aligns well with recommended practices for onion production, particularly in areas with sufficient irrigation and fertile soils [61].

The highest seed rate, greater than 16 kg/ha, was adopted by 41.5% of respondents overall, with Amibara leading at 48%, followed by Haruka (46%), Gelealo (40%), and Gewane (32%). High seed rates may lead to dense planting, which can increase competition for nutrients and water, potentially affecting bulb size. However, in areas with abundant resources, this practice can result in higher overall yields [62].

2) Sowing Method

The vast majority of producers (98.5%) across all districts used row planting, with Amibara, Gelealo, and Gewane reporting 100% adoption, and Haruka following closely with 96%. Row planting is the preferred method for onion production as it facilitates better crop management, including irrigation, weeding, and harvesting [63].

Only 1.5% of producers used broadcast sowing, with the practice reported in Amibara (2%) and Haruka (4%). Broadcast sowing is generally discouraged for onion cultivation as it can lead to uneven germination and poor plant spacing, resulting in lower yields [64].

3) Sowing Time

Most producers sowed their seeds between July and November, with the highest concentration in September (18%) and October (16.5%) across all districts. July was the most preferred sowing month in Gewane (24%) and Amibara (22%). Producers in Haruka preferred August (24%), while October was also commonly chosen by producers in Gelealo (16%). The predominance of these months reflects the region's growing season and the timing of the rainy season, which is crucial for seedling establishment [65]. A smaller number of producers (9%) reported sowing in February, with Haruka having the highest percentage (12%). February sowing is uncommon and may reflect the use of irrigation systems to support offseason planting in some areas [66].

4) Days to Remain in Nursery

Around 14% of producers reported keeping their seedlings in the nursery for 45 to 50 days, with Gelealo (18%) and Amibara (16%) leading in this practice. Shorter nursery durations can lead to weaker seedlings, potentially impacting transplant survival and yield [67]. A significant number of producers (25%) reported leaving seedlings in the nursery for 51 to 55 days, with Amibara (32%) and Gelealo (24%) leading in this practice. This duration is considered appropriate for onion seedling development, ensuring better establishment after transplanting [68]. The majority of producers (61%) reported a nursery period of 56 to 60 days, with Haruka (68%) and Gewane (66%) showing the highest adoption. This longer nursery period helps ensure strong, well-developed seedlings, which can enhance the plant's ability to withstand transplant shock and establish quickly in the field [69].

5) Transplanting Time

The most common time for transplanting was September, with 69% of respondents reporting this practice. Gelealo (42%) and Amibara (40%) had the highest proportion of September transplants. September is a prime time for transplanting in this region as it coincides with the end of the rainy season, providing favorable soil moisture conditions for seedling establishment [70]. January was the second most common transplanting month, reported by 29% of producers. Gelealo (32%) and Haruka (30%) had the highest January transplant rates. January transplanting likely aligns with irrigation availability in these areas, allowing for offseason production [71].

Another peak time for transplanting was October, with 39% of respondents reporting this practice. Gewane (30%) and Haruka (18%) were the districts with the highest rates of October transplanting. Transplanting during this time may take advantage of residual soil moisture from the rainy season [72]. The survey results reveal significant variability in nursery management and transplanting practices among the four districts. Seed rates varied widely, with a notable portion of producers using rates above 16 kg/ha, particularly in Amibara and Haruka. While row planting was nearly universal, the use of broadcast sowing by a small number of producers in Amibara and Haruka highlights the need for further education on the benefits of proper sowing methods.

The preferred sowing times were concentrated between July and October, reflecting the importance of aligning planting with seasonal rainfall patterns. Similarly, nursery durations were longest in Haruka and Gewane, where producers reported keeping seedlings for 56 to 60 days, ensuring strong plants for transplanting. The transplanting time was largely concentrated in September and January, reflecting both seasonal and irrigation-driven practices. These trends underscore the critical role of water availability in determining planting and transplanting schedules.

Table 7. *Nursery managements and translating.*

Descriptions	**Districts**								**Total (N=200)**	
	Amibara (N=50)		**Gelealo (N=50)**		**Haruka (N=50)**		**Gewane (N=50)**			
	Freq	**%**	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**
Seed rate (kg/ha)										
5 to 6	2	4	1	2	6	12	4	8	13	6.5
6 to 10	4	8	8	16	9	18	14	28	35	17.5
11 to 15	20	40	21	42	12	24	16	32	69	34.5
> 16	24	48	20	40	23	46	16	32	83	41.5
Sowing Method										
Row planting	49	98	50	100	48	96	50	100	197	98.5

Descriptions	Districts								Total (N=200)	
	Amibara (N=50)		Gelealo (N=50)		Haruka (N=50)		Gewane (N=50)			
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Broadcast	1	2	0	0	2	4	0	0	3	1.5
Sowing time										
January	0	0	0	0	0	0	0	0	0	0
February	5	10	4	8	6	12	3	6	18	9
March	0	0	0	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0	0	0	0
May	0	0	0	0	0	0	0	0	0	0
June	0	0	0	0	0	0	0	0	0	0
July	11	22	10	20	9	18	12	24	42	21
August	9	18	9	18	12	24	10	20	40	20
September	9	18	10	20	8	16	9	18	36	18
October	8	16	8	16	9	18	8	16	33	16.5
November	8	16	9	18	6	12	8	16	31	15.5
December	0	0	0	0	0	0	0	0	0	0
Days to remain on nursery										
< 45	0	0	0	0	0	0	0	0	0	0
45 to 50	8	16	9	18	6	12	5	10	28	14
51 to 55	16	32	12	24	10	20	12	24	50	25
56 to 60	26	52	29	58	34	68	33	66	122	61
> 60	0	0	0	0	0	0	0	0	0	0
Transplanting time										
January	14	28	16	32	15	30	13	26	58	116
February	0	0	0	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0	0	0	0
May	0	0	0	0	0	0	0	0	0	0
June	0	0	0	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0	0	0	0
August	8	16	6	12	10	20	10	20	34	68
September	20	40	21	42	16	32	12	24	69	138
October	8	16	7	14	9	18	15	30	39	78
November	0	0	0	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0	0	0	0

3.4.5. Irrigation

The survey results on irrigation frequency from planting to harvesting reveal varying practices across the four districts: Amibara, Gelealo, Haruka, and Gewane. This analysis is critical because irrigation management significantly impacts onion yield, bulb quality, and water use efficiency, especially in semi-arid areas like these districts.

24.5% of respondents reported irrigating their onion fields 10 times from planting to harvesting. Gewane had the highest frequency of producers adopting this practice, with 32%, followed by Haruka (26%), Gelealo (20%), and Amibara (20%). The relatively high proportion of producers irrigating only 10 times may reflect water scarcity or a strategic effort to conserve water in districts like Gewane. However, this lower frequency of irrigation could potentially result in reduced yields, as onions generally require more frequent irrigation for optimal growth, particularly during bulb formation [73].

21% of producers across all districts reported irrigating 11 times. Gewane once again showed a higher proportion of producers using this frequency (24%), followed by Haruka (22%), Amibara (20%), and Gelealo (18%). This irrigation frequency may strike a balance between conserving water and ensuring adequate moisture for the onion crop. It’s slightly more than the 10 times frequency but still less than optimal for onion cultivation, which typically requires more regular irrigation during critical growth stages [74].

The most common irrigation frequency was 12 times, reported by 27% of producers overall. Gelealo had the highest proportion at 38%, followed by Amibara (30%), Haruka (20%), and Gewane (20%). This irrigation frequency aligns more closely with recommended practices for onion cultivation, which suggests that onions need regular water to thrive, especially in semi-arid areas [70]. Producers in Gelealo may have better access to water or more awareness of irrigation's importance, which might explain their higher adoption rate of this frequency.

19.5% of respondents reported irrigating their fields 13 times. Amibara led this group with 22%, followed by Gelealo (20%), Haruka (20%), and Gewane (16%). While 13 times is more than the previously mentioned frequencies, it is still within the range of efficient water use for onion production. This suggests that producers in Amibara may be more cautious about ensuring adequate water supply, perhaps due to previous experiences with lower irrigation frequencies leading to suboptimal yields [75].

Only 8% of producers irrigated their fields 14 times, the highest frequency recorded in the survey. Haruka reported the highest percentage at 12%, followed by Amibara and Gewane, both at 8%, and Gelealo at 4%. Producers irrigating their fields 14 times likely have access to sufficient water and have recognized the importance of frequent irrigation in enhancing onion yield and quality. This frequency is closer to the ideal irrigation regime for onion cultivation, where moisture stress can severely affect bulb development and yield [76].

The survey results indicate variability in irrigation frequency across districts, reflecting differences in water availability, producer knowledge, and infrastructure. Gewane and Haruka show a greater tendency towards fewer irrigation events (10–11 times), potentially due to water scarcity or limited irrigation resources. In contrast, Gelealo and Amibara had a higher number of producers irrigating 12–13 times, which aligns better with recommended practices for onion cultivation in semi-arid environments.

According to research, onion crops in semi-arid regions such as Middle Awash require consistent irrigation throughout their growth cycle to ensure optimal development and yield. Weekly irrigation of approximately 50 mm is advised, especially during the most critical stages of bulb formation. A well-planned irrigation schedule reduces moisture stress, improves bulb size, and maximizes yield [77]. Optimal Irrigation Frequency: Weekly irrigation implies approximately 14 irrigations during the growing season, which aligns with the highest frequencies reported in the survey. However, only 8% of respondents irrigated their fields this frequently, indicating a gap between actual practices and research recommendations. Critical Stages for Irrigation: Research emphasizes the need for more frequent irrigation during the bulb formation stage to avoid yield reductions. Producers who irrigate only 10–11 times may be limiting the potential of their crops, especially during water-sensitive growth periods [78].

Table 8. *Irrigation frequency from planting to harvesting.*

Descriptions	Districts								Total (N=200)	
	Amibara (N=50)		Gelealo (N=50)		Haruka (N=50)		Gewane (N=50)			
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
10	10	20	10	20	13	26	16	32	49	24.5
11	10	20	9	18	11	22	12	24	42	21
12	15	30	19	38	10	20	10	20	54	27
13	11	22	10	20	10	20	8	16	39	19.5

Descriptions	Districts								Total (N=200)	
	Amibara (N=50)		Gelealo (N=50)		Haruka (N=50)		Gewane (N=50)			
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
14	4	8	2	4	6	12	4	8	16	8

3.4.6. Fertilization

The survey results regarding the types and amounts of fertilizers used in onion farming across the four districts Amibara, Gelealo, Haruka, and Gewane demonstrate notable uniformity in fertilizer usage patterns. However, there are differences in the specific rates of fertilizer application across districts, reflecting variability in soil fertility perceptions, agricultural practices, and access to resources. A detailed comparison of the findings is discussed below, with reference to relevant agricultural studies [79].

1) Fertilizer Types Used

A key observation from the survey is that 100% of the respondents in all districts use a combination of NPS (Nitrogen, Phosphorus, and Sulfur) and UREA fertilizers. None of the producers reported using only NPS, UREA, or compost. The widespread adoption of NPS+UREA is indicative of producers' awareness of the benefits of balanced nutrient applications in onion farming. According to [80], NPS supplies essential macronutrients critical for root and shoot development, while UREA provides the necessary nitrogen for plant growth and photosynthesis.

The absence of compost usage across all districts may point to limited access to organic fertilizers or inadequate knowledge of their benefits. Compost has been proven to improve soil structure, increase moisture retention, and reduce dependency on chemical fertilizers in onion production [81]. Therefore, integrating compost into current practices could be an area of focus for extension services aimed at promoting sustainable agriculture.

2) Fertilizer Rate for UREA (kg/ha)

Across all districts, UREA fertilizer application rates were consistently within the range of 300 kg/ha to 400 kg/ha, with no producer exceeding 400 kg/ha or applying less than 300 kg/ha. In Amibara, 40% of producers applied 300 kg/ha, while 60% applied 400 kg/ha. In Gelealo, 20% of respondents used 300 kg/ha, and 80% used 400 kg/ha. Similarly, in Haruka, 46% of producers applied 300 kg/ha, and 54% applied 400 kg/ha. In Gewane, 32% of producers used 300 kg/ha, while 68% applied 400 kg/ha. This uniformity in fertilizer application suggests a widespread adoption of similar nutrient management practices across the districts.

Overall, 65.5% of the producers applied 400 kg/ha of UREA, and 34.5% applied 300 kg/ha. This pattern suggests that most producers favor the higher UREA rate, which could be due to soil conditions that necessitate more nitrogen for better yields, especially in semi-arid regions like Amibara and Gewane, where nitrogen leaching could be a concern due to irrigation [82]. The higher rates of UREA application across the districts are in line with research suggesting that onions are heavy nitrogen feeders, requiring substantial nitrogen for optimal growth and yield [67]. However, excessive nitrogen application without proper management could lead to nutrient runoff and environmental pollution, making it crucial to balance fertilizer use with sustainable practices.

3) Fertilizer Rate for DAP (kg/ha)

The application of DAP (Diammonium Phosphate) fertilizer showed variability across the districts, with rates ranging from 200 kg/ha to 700 kg/ha, but no producer exceeded the 700 kg/ha mark. In Amibara, 10% of producers applied 200 kg/ha, 10% applied 300 kg/ha, 70% used 400 kg/ha, and 10% applied 700 kg/ha. In Gelealo, 4% of respondents used 200 kg/ha, 12% applied 300 kg/ha, 80% used 400 kg/ha, and 4% applied 700 kg/ha. In Haruka, 12% used 200 kg/ha, 30% applied 300 kg/ha, 50% applied 400 kg/ha, and 8% used 700 kg/ha. Lastly, in Gewane, 8% applied 200 kg/ha, 36% applied 300 kg/ha, 50% applied 400 kg/ha, and 6% used 700 kg/ha. This distribution highlights diverse fertilizer usage patterns, with the majority of producers in all districts favoring a 400 kg/ha application rate. Overall, 62.5% of the respondents applied 400 kg/ha of DAP, while 22% used 300 kg/ha and 8.5% applied 200 kg/ha. A smaller proportion of producers (7%) used 700 kg/ha. The predominance of 400 kg/ha applications aligns with recommendations for phosphorus fertilization in onion farming, where sufficient phosphorus is essential for early root development and energy transfer during bulb formation [83].

The use of 700 kg/ha of DAP by a small number of producers, particularly in Amibara and Haruka, could indicate either a higher phosphorus requirement in their soils or a lack of knowledge on appropriate fertilizer application rates. Studies have shown that overuse of phosphorus fertilizers can lead to soil imbalance and environmental degradation [84]. Therefore, precision in fertilizer application based on soil testing could help optimize yields and prevent excess nutrient application.

The survey indicates that all producers in the surveyed districts rely on chemical fertilizers, specifically NPS and UREA, for onion production. The widespread application of these fertilizers suggests a strong understanding of their importance in boosting yields. However, the exclusive reliance on chemical fertilizers without the integration of organic inputs like compost could limit the long-term sustainability of soil health. Moreover, while the rates of UREA and DAP application are relatively uniform across districts, the variations in application rates suggest that some producers may either lack access to soil testing or rely on general recommendations. Soil testing and site-specific nutrient management could help fine-tune fertilizer application, ensuring both yield optimization and environmental protection [85].

***Table 9.** Types and amount of fertilizer used.*

Descriptions	**Districts**								**Total (N=200)**	
	Amibara (N=50)		**Gelealo (N=50)**		**Haruka (N=50)**		**Gewane (N=50)**			
	Freq	**%**	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**
Fertilizer Type										
Only NPS	0	0	0	0	0	0	0	0	0	0
Only UREA	0	0	0	0	0	0	0	0	0	0
NPS+UREA	50	100	50	100	50	100	50	100	200	100
COMPOST	0	0	0	0	0	0	0	0	0	0
Fertilizer Rate used (UREA) (kg/ha)										
< 300	0	0	0	0	0	0	0	0	0	0
300	20	40	10	20	23	46	16	32	69	34.5
400	30	60	40	80	27	54	34	68	131	65.5
500	0	0	0	0	0	0	0	0	0	0
> 600	0	0	0	0	0	0	0	0	0	0
	50	100	50	100	50	100	50	100	200	100
Fertilizer Rate used (DAP) (kg/ha)										
200	5	10	2	4	6	12	4	8	17	8.5
300	5	10	6	12	15	30	18	36	44	22
400	35	70	40	80	25	50	25	50	125	62.5
500	0	0	0	0	0	0	0	0	0	0
600	0	0	0	0	0	0	0	0	0	0
700	5	10	2	4	4	8	3	6	14	7

3.4.7. Weed Management

The survey results on weeding frequency from planting to harvesting reveal significant variation across the four districts, although no producer weeded less than four times. Across all districts, the majority of producers weeded either four or five times, reflecting a substantial labor commitment to maintain onion fields.

In Amibara, 40% of producers weeded their fields four times, while 52% weeded five times, and 8% weeded six times. Similarly, in Gelealo, 36% weeded four times, 60% weeded five times, and only 4% weeded six times. In Haruka, weeding practices closely resembled Gelealo, with 46% of producers weeding four times, 42% weeding five times, and 12% weeding six times. Finally, in Gewane, 32% weeded four times, and 60% weeded five times, with 8% weeding six times.

Overall, 53.5% of producers weeded their fields five times, making this the most common practice across the districts. The fact that no producers weeded fewer than four times may indicate widespread awareness of the critical importance of regular weeding for optimal onion yield, especially since onions are highly sensitive to competition from weeds [86].

However, the small percentage of producers weeding six times (8% overall) might reflect a more intensive approach due to specific field conditions such as higher weed pressure or challenges in labor management. The results suggest that further extension services could focus on optimizing weeding practices to balance labor inputs with crop yield, perhaps introducing mechanization or improved herbicide use where feasible to reduce the labor burden while maintaining field cleanliness.

Table 10. *Weeding frequency from planting to harvesting.*

Descriptions	Districts								Total (N=200)	
	Amibara (N=50)		Gelealo (N=50)		Haruka (N=50)		Gewane (N=50)			
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
One times	0	0	0	0	0	0	0	0	0	0
Two times	0	0	0	0	0	0	0	0	0	0
Three times	0	0	0	0	0	0	0	0	0	0
Four times	20	40	18	36	23	46	16	32	77	38.5
Five times	26	52	30	60	21	42	30	60	107	53.5
Six times	4	8	2	4	6	12	4	8	16	8

3.4.8. Pest and Management

The survey results in Table 11 provide insight into the occurrence of insect pests and diseases across the four districts, as well as the chemical management practices employed by producers. The prevalence of pests and diseases, particularly Thrips (Thrips tabaci) and Stemphylium leaf blight, shows both district-specific trends and common challenges, highlighting the significant burden of pest and disease management in onion cultivation.

1) Insect Pests Occurrence

Thrips were the most common insect pest, affecting 34.5% of the total respondents. Haruka experienced the highest rate of Thrips occurrence at 46%, followed by Amibara (40%), Gewane (32%), and Gelealo (20%). Aphids were another prevalent pest, affecting 37% of respondents. Interestingly, Gelealo reported the highest incidence of aphids at 60%, which was significantly higher than in the other districts, such as Haruka (24%) and Amibara and Gewane (both 32%). The high aphid pressure in Gelealo could be linked to local climate conditions or previous infestations [87]. Maggots were reported by 20.5% of respondents, with Gewane having the highest occurrence (28%), while Haruka (18%), Amibara (20%), and Gelealo (16%) had somewhat similar maggot occurrence. Leafminers were the least reported insect, with only 8% overall occurrence, spread fairly evenly across districts.

2) Chemical Management of Insect Pests

Producers used a wide range of chemicals to manage these pests. The most commonly used chemicals included Ajanta 72%EC (used by 10% of producers overall), Promax 44% EC (10.5%), Karate 5% EC (9.5%), and Prostar 72% EC (8%). Each district had similar usage rates for these insecticides, reflecting their reliance on chemical control strategies. Gelealo had a relatively higher rate of Promax use (14%), possibly due to the higher aphid pressure in that district. There was also a general spread of usage across different chemicals, which may indicate producers' adaptation to the resistance patterns of local pest populations or availability of products in the market [88].

3) Disease Occurrence

Stemphylium leaf blight was the most common disease, with 59% of respondents experiencing it. Haruka had the highest rate of this disease (76%), followed by Gewane (68%), Amibara (52%), and Gelealo (40%). The high prevalence in Haruka could be attributed to favorable conditions for fungal growth, such as humidity or inadequate disease management practices [89]. Purple blotch was another major disease, affecting 41% of producers overall. Gelealo reported the highest occurrence (60%), while Amibara had a lower rate (48%). The spread of purple blotch across the districts suggests widespread issues with field hygiene, moisture control, or the presence of resistant disease strains.

4) Chemical Management of Diseases

To manage diseases, producers primarily relied on chemicals like Ridomil Gold MZ 68 WG (used by 25% of respondents), Manzeb M® 72% WP (21%), and Agrozeb 80 WP (20.5%). Amibara had the highest use of Ridomil (32%), likely due to its effectiveness in managing purple blotch and leaf blight. Gelealo showed a preference for Manzeb M® 72% WP (26%), which may be related to the specific disease pressure in that district. Other chemicals like Tilt 250 EC and Revolution 325 SC were used less frequently, suggesting that certain chemicals might be more regionally adapted or more accessible based on local agro-dealer networks.

The survey highlights the considerable challenges of pest and disease management in onion cultivation across all districts, with heavy reliance on chemical controls [90]. The varied occurrence of pests like Thrips and aphids, and diseases like Stemphylium leaf blight and purple blotch, calls for a more integrated pest management approach, combining cultural, biological, and chemical methods. Additionally, the significant use of chemical pesticides and fungicides raises concerns about long-term soil health and the risk of pesticide resistance, emphasizing the need for sustainable agricultural practices.

Table 11. *Disease and Insect pest occurrence and its management.*

Descriptions	Districts								Total (N=200)	
	Amibara (N=50)		Gelealo (N=50)		Haruka (N=50)		Gewane (N=50)			
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Insects Occurance										
Thrips (*Thrips tabaci*)	20	40	10	20	23	46	16	32	69	34.5
Aphids	16	32	30	60	12	24	16	32	74	37
Maggot (*Delia antiqua*)	10	20	8	16	9	18	14	28	41	20.5
Leafminers	4	8	2	4	6	12	4	8	16	8
Chemical used for insect pest management										
Promax 44% EC	5	10	7	14	4	8	5	10	21	10.5
Karate 5% EC	6	12	4	8	5	10	4	8	19	9.5
Prostar 72% EC	4	8	4	8	4	8	4	8	16	8
Proof 72%EC	4	8	4	8	5	10	4	8	17	8.5
Spark 250 WG	4	8	4	8	4	8	5	10	17	8.5
Tangent 175 SC	5	10	4	8	5	10	5	10	19	9.5
Golbe	4	8	5	10	4	8	5	10	18	9
Procare 72%EC	5	10	4	8	5	10	4	8	18	9
Jentil	4	8	5	10	4	8	4	8	17	8.5
Ajanta 72%EC	5	10	5	10	5	10	5	10	20	10
Agro-theote 40%EC	4	8	4	8	5	10	5	10	18	9
Diseases Occurance										
Purple Bloch	24	48	30	60	12	24	16	32	82	41
Stemphylium leaf blight	26	52	20	40	38	76	34	68	118	59
Chemical used for disease management										
Revolution 325 SC	8	16	10	20	12	24	11	22	41	20.5
Agrozeb 80 WP	10	20	8	16	9	18	14	28	41	20.5
Tilt 250 EC	6	12	9	18	6	12	5	10	26	13
Ridomil Gold MZ 68 WG	16	32	10	20	14	28	10	20	50	25
Manzeb M ® 72% WP	10	20	13	26	9	18	10	20	42	21

3.4.9. Harvesting and Post Harvest Handling

The survey results in Table 12 provide valuable insights into the harvesting and post-harvest handling practices for onion production across the districts of Amibara, Gelealo, Haruka, and Gewane. These practices are critical for ensuring the quality and marketability of onions, which can significantly affect the economic returns for producers.

1) Harvesting Indicators

The results indicate that various indicators are utilized by producers to determine the optimal time for harvesting onions. Among these indicators, the most commonly reported was "leaf yellowing and falling," cited by 29% of respondents, particularly from Amibara (32%) and Gewane (32%). This is consistent with best practices, as yellowing leaves often signal that the bulbs have reached maturity and are ready for harvest (Abdullah et al., 2021). Other indicators, such as "neck softening" (15.5%) and "bulb size" (21.5%), were also significant, reflecting producers' focus on physical characteristics that indicate maturity.

Conversely, less emphasis appears to be placed on indicators like "bulb firmness" (7.5%) and "dry outer skin" (11.5%), which are also important for assessing bulb quality. The lack of attention to these indicators could lead to harvesting immature bulbs, potentially resulting in reduced shelf life and marketability [91].

2) Post-Harvest Handling

In terms of post-harvest handling, the practices employed by producers are essential for maintaining onion quality. The survey shows that a considerable portion of respondents engaged in "cleaning" (30%) and "packaging" (34.5%), which are critical for reducing post-harvest losses. Cleaning removes dirt and contaminants, while proper packaging protects onions from mechanical damage during transport and storage [92].

However, the low frequency of practices like "curing" (14.5%) and "sorting and grading" (9%) is concerning. Curing is vital for reducing moisture content and improving storage life by allowing the outer skins to dry and harden [93]. The limited use of sorting and grading could indicate missed opportunities for improving market access and profitability, as graded onions typically fetch higher prices [94].

3) Yield Obtain

Regarding yield, the survey results indicate a range of yields across the districts. The highest proportion of respondents reported yields between 251 and 300 q/ha (36%), with the district of Haruka showing the best performance (40%). This yield range is consistent with research indicating that well-managed onion crops can produce substantial yields, especially under optimal conditions [95]. Conversely, the absence of producers reporting yields above 350 q/ha suggests that there may be underlying challenges in cultivation practices or environmental conditions that limit higher productivity.

In conclusion, while the survey reveals a foundational understanding of harvesting and post-harvest practices among onion producers, there remains significant room for improvement. Emphasizing proper curing, sorting, and grading could enhance onion quality and marketability, leading to better economic outcomes for producers in the Middle Awash area. According to [2], under optimal conditions including proper irrigation frequency, balanced fertilization, and integrated pest management onion yields can reach 250–350 q/ha. The survey results align with these recommendations, indicating that many producers are achieving relatively high yields due to effective crop management. However, further improvements in these areas could help push yields beyond the upper limit of this range.

Table 12. *Harvesting and Post harvest handling of onion.*

Descriptions	Districts								Total (N=200)	
	Amibara (N=50)		Gelealo (N=50)		Haruka (N=50)		Gewane (N=50)			
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Harvesting Indicators										
Bulb Size	6	12	10	20	11	22	16	32	43	21.5
Neck Softening	10	20	8	16	9	18	4	8	31	15.5
Dry Outer Skin	4	8	10	20	6	12	3	6	23	11.5
Leaf Yellowing and falling	16	32	14	28	12	24	16	32	58	29
Flower Induction	8	16	4	8	10	20	8	16	30	15
Bulb Firmness	6	12	4	8	2	4	3	6	15	7.5
Post harvest handling										

Descriptions	Districts Amibara (N=50)		Gelealo (N=50)		Haruka (N=50)		Gewane (N=50)		Total (N=200)	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Curing	5	10	11	22	3	6	10	20	29	14.5
Sorting and Grading	1	2	9	18	4	8	4	8	18	9
Cleaning	20	40	10	20	14	28	16	32	60	30
Packaging	20	40	10	20	23	46	16	32	69	34.5
Avoid Mechanical Damage	4	8	10	20	6	12	4	8	24	12
Yield Obtaind Qt/ha)										
150 to 200	12	24	10	20	8	16	11	22	41	20.5
201 to 250	12	24	14	28	16	32	13	26	55	27.5
251 to 300	18	36	16	32	20	40	18	36	72	36
301 to 350	8	16	10	20	6	12	8	16	32	16
351 to 400	0	0	0	0	0	0	0	0	0	0

3.4.10. Storage and Marketing

The survey results presented in Table 13 provide an overview of storage practices and marketing strategies employed by onion producers across four districts: Amibara, Gelealo, Haruka, and Gewane. These factors are critical for understanding the overall post-harvest handling of onions, influencing both the quality of the produce and the economic viability of onion farming.

1) Storage Practices

The data reveal a varied approach to storage time among the districts. A substantial proportion of respondents (31.5%) reported storing onions for 1 to 5 days, with Gewane showing the highest percentage (36%). This short storage duration may indicate either immediate market sales or insufficient facilities for longer-term storage. The 1 to 5-day storage period aligns with practices aimed at minimizing spoilage and maintaining quality, especially considering onions' susceptibility to diseases during prolonged storage [96].

Storage times of 6 to 10 days and 11 to 15 days accounted for 23.5% and 28% of responses, respectively. These durations may reflect an effort to extend the selling period without incurring significant losses due to rot or sprouting [97]. However, only 17% of producers reported storing onions for more than 16 days, which highlights a potential area for improvement. Investing in better storage techniques or facilities could enable producers to retain their produce longer and sell during off-peak times, thereby increasing their profit margins.

2) Marketing Channels

Marketing strategies reveal that brokers play a significant role in the onion supply chain, as evidenced by 55.5% of respondents relying on them for sales. This reliance suggests a lack of direct market access for many producers, potentially limiting their bargaining power and profit margins [98]. The predominance of brokers could also indicate challenges in reaching broader market channels, such as local or wholesale markets, with only 11.5% of respondents selling directly to consumers.

Local markets were utilized by 11.5% of the respondents, with a notably low frequency of wholesale market activity (0%). The absence of exports and cooperative marketing further emphasizes the limited scope of market engagement among these producers. These findings suggest that producers may benefit from training or resources that enhance their marketing skills, allowing them to explore alternative channels that could provide better financial returns [99].

In summary, the survey results indicate that onion producers in these districts primarily engage in short-term storage and rely heavily on brokers for marketing their produce. Enhancing storage practices and diversifying marketing strategies could lead to improved profitability and sustainability for onion producers. Efforts to improve storage infrastructure and market access should be prioritized to ensure that producers can maximize the value of their harvests while minimizing post-harvest losses.

Table 13. *Storage and Marketing.*

Descriptions	Districts								Total (N=200)	
	Amibara (N=50)		Gelealo (N=50)		Haruka (N=50)		Gewane (N=50)			
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Storage Time (days)										
1 to 5	15	30	14	28	16	32	18	36	63	31.5
6 to 10	13	26	12	24	9	18	13	26	47	23.5
11 to 15	14	28	15	30	16	32	11	22	56	28
> 16	8	16	9	18	9	18	8	16	34	17
Marketing										
Farmgate Sales	7	14	14	28	16	32	18	36	55	27.5
Brokers	29	58	25	50	31	62	26	52	111	55.5
Local Markets	9	18	7	14	2	4	5	10	23	11.5
Wholesale Markets	0	0	0	0	0	0	0	0	0	0
Consumers	5	10	4	8	1	2	1	2	11	5.5
Export Markets	0	0	0	0	0	0	0	0	0	0
Cooperative Marketing	0	0	0	0	0	0	0	0	0	0

4. Challenges and Constraints of Onion Production in Middle Awash Area

The qualitative data gathered through focus group discussions (FGDs) and field observations provides valuable insights into the challenges faced by onion producers in the Middle Awash area. The thematic coding process identified common issues in seed access, entrepreneurship, and market opportunities, highlighting the root causes of production constraints. These insights complement the quantitative data, offering a more comprehensive understanding of the production environment. Below, the key challenges are scientifically interpreted:

4.1. Input (Seed, Chemicals, and Fertilizers)

Access to quality inputs, particularly seeds, chemicals, and fertilizers, emerged as a significant constraint. Producers reported difficulties in acquiring high-quality seeds, often resulting in lower yields. Additionally, chemical inputs and fertilizers are either too expensive or unavailable when needed, affecting pest management and soil fertility [51]. These limitations could explain the uniform reliance on NPS+UREA as observed in fertilizer use data from the quantitative survey.

4.2. Soil Salinity

Soil salinity is a common problem in the Middle Awash, primarily due to the use of irrigation systems in areas prone to waterlogging and poor drainage. High salinity negatively impacts crop growth, reduces productivity, and limits the type of crops that can be grown. This issue is corroborated by field observations and has been noted in previous studies in similar agro-ecological zones [100].

4.3. Irrigation Facilities (Canal Maintenance)

Producers frequently cited issues with irrigation infrastructure, particularly the need for regular canal maintenance. Poorly maintained irrigation systems lead to inefficient water distribution, affecting the growth cycle of onions, especially in critical stages like transplanting. This challenge reflects the survey data, where irrigation frequency and inconsistency varied between districts. Maintaining proper irrigation systems is crucial for consistent water availability, which is vital in this arid region [101].

4.4. Climate Change (Unexpected Rainfall During Harvest)

Unexpected rainfall during harvesting was reported as a growing challenge due to climate variability. This disrupts the drying process of onions, leading to quality deterioration and post-harvest losses. The timing of sowing and transplanting is heavily influenced by climatic conditions, and this disruption impacts producers' decision-making, which could be reflected in the seasonal limitations in sowing times observed in the survey data [102].

4.5. Market Problems

Market access issues were highlighted, with many producers relying on brokers and intermediaries to sell their produce, leading to low prices and limited bargaining power. The qualitative data reveals the frustration among producers with inconsistent market demand and price fluctuations, which aligns with the survey findings where most producers rely on brokers for marketing (55.5%). This dependency limits direct access to more profitable market channels [103].

4.6. Crop Perishability

Onions are highly perishable, and poor storage conditions exacerbate post-harvest losses. Producers in the Middle Awash area struggle with proper storage facilities, as indicated by the short storage times reported in the survey. Most producers stored onions for 1 to 15 days, reflecting their vulnerability to spoilage. The absence of adequate storage infrastructure is a key constraint, affecting the overall profitability of onion production [30].

4.7. Not Using Research Recommendations

Another challenge identified was the limited adoption of research-based recommendations. Many producers continue to use traditional practices despite the availability of improved techniques. This gap between research and practice often results in suboptimal yields. Encouraging the dissemination and practical application of research findings could help bridge this gap [104].

4.8. Disease and Insect Infestation

The survey highlighted significant challenges related to pests and diseases, such as Thrips tabaci and purple blotch. Producers reported difficulties in managing these pests due to inadequate access to effective chemicals or lack of knowledge about proper pest control methods. The qualitative data indicates a need for better pest management strategies and training in the use of appropriate chemicals, which is supported by the survey data on the usage of different insecticides and fungicides [105].

4.9. Human Power

Labor shortages, particularly during peak seasons such as transplanting and harvesting, were identified as a constraint. Many producers rely on family labor or local workers, but the availability of labor is often limited, especially during critical periods. This labor gap slows down operations, leading to delayed harvesting or improper crop handling, which in turn reduces the market value of onions [106].

The challenges identified through the FGDs and field observations, such as input shortages, soil salinity, irrigation issues, climate change impacts, and market constraints, complement the quantitative findings. Together, these insights provide a holistic view of the constraints facing onion producers in the Middle Awash area, highlighting the need for improvements in infrastructure, input availability, and market access to enhance the sustainability of onion farming in this region.

4.10. Lack of Known or Certified Seed

The use of unknown or uncertified seed in agricultural production poses a significant challenge in the dissemination of diseases and insect infestations. Seeds that are not properly vetted or certified by regulatory authorities may carry pathogens or pests, contributing to widespread infestations and increased vulnerability of crops. This issue is particularly prominent in regions where producers rely on informal seed systems or lack access to high-quality, certified seeds [107].

To mitigate the dissemination of diseases and pests through seeds, it is crucial to improve access to certified, disease-free seeds [108]. Strengthening seed systems through government regulation, certification programs, and producer training on the importance of seed quality can play a vital role in reducing disease and pest outbreaks. Certified seeds are treated with fungicides or insecticides and undergo rigorous testing to ensure they are free from contaminants, which helps limit the spread of pests and diseases [108].

5. Conclusions and Recommendations

5.1. Conclusions

The assessment of onion bulb and seed production potentials in the Gebiresu Zone of the Afar National Regional State underscores both opportunities and challenges for sustainable agriculture across the districts of Amibara, Gewane, Haruka, and Gelealo. While onion cultivation is well-established and producers have a foundational understanding of key agronomic practices, the variability in the implementation of these practices across districts significantly impacts yield outcomes and overall agricultural productivity.

Amibara exhibited a relatively higher adoption of recommended practices, particularly in irrigation and balanced fertilizer use, but remains challenged by pest and disease pressures, notably from Thrips and Stemphylium leaf blight. The frequent use of chemical pesticides in this district, without integrated pest management (IPM), poses risks of pesticide resistance and environmental degradation. This highlights the need for promoting IPM strategies.

In Gewane and Haruka, water scarcity and inconsistent irrigation practices were major barriers to achieving optimal yields. These districts require improvements in irrigation infrastructure and water management practices to enhance both water-use efficiency and productivity. Additionally, severe pest infestations further reduce crop yields, necessitating targeted interventions in pest control.

Gelealo faced issues related to inconsistent fertilizer application rates and the absence of IPM practices, which contributed to lower yields. Furthermore, the reliance on local brokers for market access in Gelealo and Gewane constrains profitability, limiting producers ' economic opportunities and disincentivizing improvements in agricultural practices.

Onion seed production across all districts is vulnerable by climatic challenges, pest outbreaks, and insufficient technical knowledge on seed harvesting and storage. Investments in producer training and infrastructure, particularly storage facilities, are critical to improving seed quality and availability, thereby reducing reliance on external sources.

In general, while onion production in the Gebiresu Zone shows substantial potential, achieving sustainable growth will require addressing district-specific challenges. Improving pest and disease management, optimizing irrigation practices, standardizing fertilizer use, and enhancing seed production through better technical knowledge and infrastructure are key to increasing yields and ensuring long-term agricultural sustainability in the region.

5.2. Recommendations

1) *Integrated Pest and Disease Management (IPM)*: To mitigate the high occurrence of pests such as Thrips and Aphids, and diseases like Stemphylium leaf blight, there is a need to implement integrated pest management strategies. This includes promoting crop rotating and chemical treatments to prevent resistance, and encouraging the use of disease-resistant onion varieties.
2) *Producers Training and Capacity Building*: Variations in management practices across districts indicate a gap in technical knowledge. Training programs should be enhanced to standardize best practices in irrigation scheduling, fertilizer application, and pest management. Producers need to be educated on sustainable practices to avoid over-reliance on chemical inputs and to promote long-term soil health.
3) *Water Management and Irrigation Efficiency*: Given the region's arid climate, improving irrigation systems and promoting water-use efficiency is critical. Introducing water-saving technologies such as drip irrigation and providing training on proper scheduling will help optimize water use and enhance yields.
4) *Support for Onion Seed Production*: To enhance local seed production, targeted interventions are required to improve producers' knowledge and infrastructure for seed harvesting, processing, and storage. The establishment of seed production cooperatives and linkages with research institutions can help overcome technical barriers.
5) *Soil Health and Fertility Management*: Promoting balanced fertilizer application and organic matter enrichment through the use of compost and other organic inputs should be prioritized to maintain soil fertility. Encouraging the use of soil tests to determine the precise nutrient needs of crops will prevent nutrient wastage and environmental degradation.
6) *Access to Inputs and Extension Services*: The government and development partners should ensure that producers have consistent access to quality inputs such as fertilizers, seeds, and pest control products. Strengthening agricultural extension services to provide tailored support for each district will help improve adoption rates of modern practices.
7) *Post-Harvest Handling and Storage*: Investments in improved storage facilities and post-harvest handling practices, such as proper curing and sorting, should be prioritized to reduce spoilage and increase market value.

Abbreviations

FGDs	Focus Group Discussions
WARC	Werer Agricultural Research Center
EIAR	Ethiopian Institute of Agricultural Research

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Author Contributions

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Conflicts of Interest

The authors declare no conflicts of interest.

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Biography

Yitages Kuma Beji, a dedicated horticultural researcher at the Ethiopian Institute of Agricultural Research (EIAR), holds a B.Sc. in Plant Sciences from Ambo University (Jun. 24, 2010) and an M.Sc. in Horticulture from Hawassa University (Feb. 20, 2017). With over a decade of experience, he has advanced from Junior Researcher to Researcher-I and Crop Research Process Head at the Werer Agricultural Research Center. Yitages specializes in horticultural crop research, statistical data analysis, and sustainable agricultural practices, contributing significantly to field experimentation, technology demonstration, and participatory research approaches. An accomplished academic, he has authored several publications on crop improvement and demonstrations, reflecting his commitment to enhancing agricultural productivity and resilience in Ethiopia.

Shimelis Alemayehu Seta, an Assistant Researcher II in a Plant Breeding Researcher at the Ethiopian Institute of Agricultural Research (EIAR), holds a B.Sc. in Plant Sciences from Ambo University (Feb. 2012) and an M.Sc. in Plant Breeding from the same institution (Jan. 2017). Recognized for his significant contributions, he has been designated as a Professional Plant Breeder by EIAR and has actively participated in national research collaborations aimed at improving irrigated wheat productivity and sustainability. Proficient in data analysis using tools such as R and SAS, Shimelis is adept at developing research proposals, analyzing experimental data, and providing recommendations to enhance agricultural practices among farmers and agro-pastoralists in Ethiopia, showcasing his dedication and expertise in the field.

Research Field

Yitages Kuma Beji: Plant Breeding and genetics, Plant agronomy and physiology, Biotechnology, Horticultural crop improvements, Root crops research and improvements, Agriculture.

Shimelis Alemayehu Seta: Plant Breeding and genetics, Plant agronomy and physiology, Biotechnology, Horticultural crop improvements, Root crops research and improvements, Agriculture.