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RESEARCH ARTICLE

Promotion of Improved Onion (Nafis Variety) Production Technology under Irrigated Conditions in Nyangatom District, Low Land Area of South Omo Zone

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Abstract: Onion is an important cash crop that could enhance the income of agro-pastoralists in Nyangatom woreda as the area has huge potential for water availability from the Omo River and fertile land. However, access to improved onion variety is limited in the area. Thus, this study aimed to demonstrate the improved onion variety with its agronomic management in the production season. Onion growers were purposely selected and have taken training on onion production by using recommended doses of fertilizers, pesticides, irrigation, and suitable agronomic practices. Each agro-pastoralist covered 0.064 hectares of land by improved onion. The recorded data from the field experiment and agro-pastoral perceptions were analyzed through simple descriptive and preference ranking tools. From the result of the demonstration trial, the mean bulb yield of the improved onion (Nafis variety) was 125 qt/ha. The average return obtained from the sale of onion bulbs per hectare was 334,925 Ethiopian birr. Moreover, the benefit-to-cost ratio of improved onion production was 8.34:1, which indicates the benefits outweigh the costs, suggesting a positive return on improved onion production in the area. The agro-pastoralist's preference further showed that the Nafis variety was the best one or superior to the local variety in terms of its high-yielding ability, dark green leaf color, medium bulb size, and market preference. Therefore, the authors suggest the respective government and non-government bodies to further promote improved onion in the area.

Keywords: Promotion; Improved onion; Perception; Cost benefit ratio; Agro-pastorals

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1. Introduction

Onion is one of the major cash crops in Ethiopia and its production plays a significant role in the country's agricultural economy. It provides income and employment opportunities for thousands of farmers and laborers involved in its cultivation, harvesting, processing, and marketing [1]. Onion is a highly demanded culinary ingredient, making their production lucrative for farmers. They have a wide range of applications in the cooking and food processing industries, ensuring a constant market demand [2]. Onion is rich in essential nutrients, vitamins, and antioxidants and consumer awareness about healthy eating habits increases, and the demand for nutritious and organic onions continues to rise, thereby benefiting onion producers [3]. Onion can be grown in a variety of locations, but the optimum altitude range for its production is between 500 and 2200 m.a.s.l and the temperature ranges between 12.4 ºC to 31.3 ºC [4]. Onion production in Ethiopia is contributing to the country's agricultural sector. The economic stability and employment opportunities it provides are important for the country's development [5]. However, the productivity of onions is decreasing over time due to different production constraints such as lack of improved variety, disease and pest infestation, weak extension supports and soil fertility decline in the country [6,7].

The South Omo Zone is one of the zones in the Southern Nations Nationality and Peoples Region (SNNPR) and is known for potential large investment lands, irrigation water access from Omo, Woito, and other small rivers. Onion production is one of the significant agricultural activities which is dominated in Bena-Tsemay, Dasenech and Debub Ari woredas of the zone for domestic consumption to meet zonal demand and also supplied to other neighboring zones. Even though South Omo Zone has great potential for onion production with year-round irrigation water from Omo, Woito and other small rivers and fertile land, agro-pastorals were less involved in improved onion production and even most farmers/agro-pastorals in South Omo Zone use their own local varieties, which resulted in lower yield per hectare [8]. Thus, it calls for research efforts regarding improved variety and agronomic management to enhance the production and productivity. In an effort to address these issues, Jinka Agricultural Research Center (JARC) conducted a field experiment to select well-adapted varieties and the optimum blended fertilizer rate at Dasenech in 2019 and Bena-Tsemay in 2020 production seasons under irrigation conditions. Nafis variety with 100 kg/ha of NPSB blended fertilizer rate gave better yields in the field experiment. The onion (Nafis variety) yield obtained from the experiment was 23 to 28 t/ha in the area. Besides, agro-pastoralists and farmers are not in a position to use this improved onion variety (Nafis) because they lack awareness regarding this improved onion variety and its agronomic management. As of these and other production constraints, Jinka Agricultural Research Center conducted the agro-pastoral based field demonstration trial with the objective of demonstrating and promoting improved onion (Nafis variety) with its agronomic management to improve the agro-pastorals livelihoods. Besides, it was aimed at creating awareness among agro-pastoralists about improved onion production technologies to help them get a better income.

2. Materials and Methods

2.1 Description of the Experimental Site

A demonstration trial was conducted in Nyangatom Woreda which is located in the south Omo zone of the Southern Nations, Nationalities, and Peoples' Region (SNNPR) in Ethiopia. It is situated in the southwestern part of the country, bordering South Sudan to the west. It is located at 5°05'-5°21' North latitude and 35°55'-36°14' East longitude, and the altitude lies between 380 and 497 meters above sea level. The total population of the district is estimated to be 11375; of those 11187 were male and 22562 were female [9]. They are predominantly nomadic or semi-nomadic, relying on herding cattle, goats, and sheep as their primary means of subsistence. The Nyangatom people have a distinct culture, traditional practices, and a unique language that is a part of the Nilo-Saharan family. The woreda is characterized by a diverse landscape, including vast grasslands, arid deserts, and rocky hills. The Omo River, which flows through this area, provides a crucial water source for both human and animal populations. The natural resources and biodiversity in Nyangatom Woreda are significant, attracting visitors interested in exploring the diverse flora and fauna. Pastoralism in the woreda relies on livestock rearing for their livelihood. They raise cattle, goats, and sheep, and their lives revolve around herding and managing their livestock. Besides pastoralism, agriculture is also practiced, primarily in areas with suitable soil and adequate rainfall. The common crops cultivated by the Nyangatom people include sorghum, maize, millet, and beans.

2.2 The Research Site and Agro-pastoral Selection

Nabusmeria Kebele from the Nyangatom woreda was purposefully selected based on its onion production potential. The selection was done in consultation with the respective woreda and South Omo Zone Agricultural and Natural Resource Offices. In the Nabusmeria Kebele,

community level awareness was created to select agro-pastoralists for the research experiment, and JARC identified one improved onion-producing group (PAPREGs) by giving due consideration to gender, which contained about 25 agro-pastoralist members (11 males and 14 females). The selected agro-pastoral areas for this research experiment were notified to the community. Then, the host agro-pastoralists, who have an interest in onion production technology, have access to irrigation water and are willing to manage and allocate land for the demonstration implemented the research experiment. Finally, from the members of the host agro-pastorals, one chairperson who is responsible for coordinating the group members was selected as a liaison between the group and the researchers, and one secretary who is responsible for record keeping was selected during this research experiment.

2.3 Planting and Agronomic Management

A high-quality onion seed (Nafis variety) was used for planting. The recommended seed rate of 4 kg/ha was sown. After 40 days, the sown seed was grown and ready for planting and uniform medium-sized seedlings were carefully transplanted in experimental fields at 3 or 4 leaf stages. Planting was done on 1.6 hectares of host agro-pastoralist fields. Agro-pastoralist planted the seedlings in 40 cm water furrows with 20 cm rows on beds and 5 cm between plants. 100 kg/ha of NPSB was applied at planting time, 150 kg/ha of Urea at 50% at planting, and the remaining 50% after 35 transplants. As per the recommendations of Ofga et al. [10] the experimental field was irrigated depending on the moisture condition of the soil (5-7 days). A total of 2.5 liter of Karate @5% and 2 kg Mancozeb were used. The weeding, hoeing, irrigating, pest management, harvesting time, and post-harvest handling was conducted timely by the pastoral/agro pastoral research and extension group with intensive follow-up of researchers and experts.

2.4 Training and Awareness Creation

Training materials such as production manuals that agro-pastorals can take home for future reference were provided and training was given to twenty-five agro-pastoralists who were members of PAPREGS, three development agents of kebele and two woreda agricultural experts to share their knowledge and experiences. Practical demonstrations were provided to give agro-pastorals hands-on experience with the onion production techniques which allowed them to see the benefits and implementation process directly. Moreover, the training was focused on nursery preparation, land preparation, sowing the seed, chemical application, fertilizer rate, irrigation frequency and time of application and all other agronomic practices for improved onion production.

2.5 The Role of Each Actor and Responsibility for Demonstration Trial, Follow-up, and Evaluation

In the early beginning, there was a discussion among the stakeholders on the roles and responsibilities for demonstration trial implementation, follow-up, and evaluation. Accordingly, the roles and responsibilities of each stakeholder were identified as follows (Table 1). Researchers discussed with agro-pastorals and identified their technology demand; developed a proposal, organized PAPREG members and delivered training, implemented demonstration trials with PAPREGs, provided appropriate technical information, and processed data to verify the recommendation. Besides, they analyzed the data collected during the demonstration trial and subsequent follow-up activities to evaluate the overall effectiveness, user satisfaction, and performance of onion production in the area. Low Land Livelihood Resilient Project (LLRP) and Southern Agricultural Research Institute (SARI) were the demonstration trial organizers who were responsible for planning and executing a trial phase where users could test and provide feedback on the improved onion production. They coordinate the logistics and collect feedback to evaluate the performance and usability of the system. The Woreda office has efforts to collaborate in site selection and follow-up of the implementation of the demonstration trial. Extension workers are responsible for mobilizing resources and facilitating the implementation activities. They create awareness for the PAPREG members, integrating it with the stakeholders, and ensuring its effectiveness in providing accurate and relevant information. They also maintained detailed records of inputs, practices, yields, and any observations throughout the onion production cycle.

Agro-pastorals are the participants in the demonstration trial. They are direct beneficiaries who get training on the onion production technologies and implement them on the trial site. Share information with each other keep a record of any activities in the field and provide to the researchers for further improvement of the onion production. They play a crucial role in performing field trials and providing feedback on its implementation and any issues encountered.

2.6 Field Day and Agro-pastoralist's Perception

At the end of the field activity (crop maturity stage), agro-pastorals field day was conducted to further promote

Table 1. Actors and responsibility of each stakeholder.

Stakeholders	Roles and responsibilities of each stakeholder
JARC (Researchers)	● Listened to what agro-pastoralist says and identified their technology demand ● Developed proposal and Organized PAPREG ● Delivered trainings and implemented project activity ● Provided appropriate technical information ● Processed data to verify the recommendation
LLRP and SARI	● Review and comment on proposal ● Released fund on time, monitored on-farm activity
District offices	● Collaborated in PAPREGS formation ● Site selection, planting and follow up of implementation
Extension workers	● Mobilized resource and facilitated activities implementation ● linked PAPRG member and Keep activity records
Agro-pastoralists	● Managed trials and discuss progress among PAPRG member ● Provided information to others and keep activity record etc.

the onion production technology. Field day events are a means of transferring new agricultural information like improved onion production technologies to agro-pastorals, farmers, development agents and key stakeholders. Consequently, a total of 50 agro-pastoralists (20 men and 30 women), 6 development agents and 4 experts from district agricultural offices, 6 researchers, and 34 different stakeholders from federal, regional and zonal were participated in the field day. Besides, the field day program was communicated on the news program by Debub television to disseminate information to the wider public view. A total of 120 leaflets were distributed to the participants which describe the production, agronomic practices, and overall management of improved onion varieties. Finally, at the end of the field visit, a group discussion was held to grasp agro pastoralists' feedback on the strengths and weaknesses of the improved onion variety. Additionally, socioeconomic and perception data was collected by face-to-face interviews with 25 PAPREGs members who produced onion and research extension groups using structured questionnaires prepared for this purpose.

2.7 Method of Data Analysis

Both qualitative and quantitative data were collected from early plantation to final harvesting. Qualitative data such as the agro-pastoral perception towards improved onion production was collected. Quantitative data such as the early maturity and bulb yield were collected. The collected data were analyzed using simple descriptive statistics like percentages and mean. A benefit-cost ratio was used to analyze the cost of production and profit from the business enterprise.

3. Results and Discussion

3.1 Yield Performance of Onion Production

The result of the study revealed that the productivity of improved onion (Nafis variety) with its technology packages gave better yield than the local variety with existing agro pastoralists' practice. Thus, the mean bulb yield of improved onion was 125 quintals per hectare (Table 2). This greater yield was achieved through the proper use of recommended technology packages such as the use of the improved Nafis variety with its proper agronomic management. This study by Tadesse [11] reported that the improved Nafis variety gave higher bulb yield among other onion varieties in Bena-Tsemay and Dasenech districts. Similarly, the better yield of Nafis as compared to Bombay Red and local was reported [12]. The better yield in the demonstration trail shows the production of onion in the area is feasible. The minimum and maximum bulb yield attained by each agro pastorals from a plot area of 0.064 ha were 6.3 and 9.7 quintals whereas the mean yield was 8 quintals.

Table 2. Yield data of onion produced by PAPREGs.

Beneficiaries	Land coverage (ha)	Average yield Q/ha	Total yield (Q)
Nafis variety			
25 agro pastorals	1.6	125	200
Per agro pastorals plot of 0.064 ha	Min	Max	Mean
	6.3	9.7	8

3.2 Agro-pastoral Perception of Improved and Local Onion Varieties

It is important to note that specific agro-pastoral perceptions of improved onion production can vary among individuals. Hence, on-ground consultations with agro-pastoralists would provide a more comprehensive understanding of their perception and facilitate the successful adoption of improved onion production methods. Agro-pastoralists might assess whether adopting improved techniques leads to higher onion yields, better bulb quality, or reduced post-harvest losses. This evaluation is crucial for economic viability and maintaining market competitiveness. As shown in Table 3, six criteria were set out in discussion with agro-pastorals to select the varieties in their traits with respect to the area they are producing. Accordingly, the important traits of onion used to select the Nafis variety were disease resistance, insect pest resistance, bulb size, bulb yield and marketability. Agro-pastoralists were interested and chose the improved onion in all traits provided as criteria but their first choice was in terms of bulb size as compared to their local practice. Accordingly, agro pastoralists' showed interest in the production of the Nafis onion variety mainly because of its uniformity in bulb size, disease and insect pest resistance, and other parameters. As indicated in the table, the weighted ranking matrix demonstrated that improved onion was preferred by agro-pastoralist in all traits as it showed better scores in bulb yield, bulb size, marketability, insect pest resistance and disease resistance. The study by Yesuf Sirba et al. [12] and Kitila et al. [13] demonstrated Nafis variety was selected by beneficiaries using similar selection criteria of improved onion variety used in this study.

3.3 Economic Returns and Costs of Onion Production

The economic returns and costs of onion production can vary depending on various factors such as location, scale of production, input costs, market demand, and productivity. Costs of production included in this study are expenses of labor, seeds, fertilizers, pesticides and irrigation. Yield per hectare is an important factor in determining economic returns. Higher yields can offset some of the production costs and result in increased profitability. The prices of onions fluctuate based on supply and demand dynamics, and seasonal variations, and to assess the economic returns of onion production, it's important to develop a comprehensive budget considering all costs and estimating potential revenues based on market conditions and projected yield (Table 4). The land was taken as a fixed asset in the assessment of its opportunity cost which is 2000 Ethiopian birr per hectare in the area at the prevailing land renting. Costs of irrigation, land preparation, weeding and chemical application, chemical, seed, fertilizer, and hired labor were calculated based on the existing market price of inputs during the experimental period which summed as 38075 Ethiopian birr per hectare. The total cost was estimated by adding up variable costs and fixed costs which was 40075 Ethiopian birr per ha.

The income from onion production per hectare was calculated as the multiple of an average yield of onions per hectare and the market price of onion at the time of harvesting. Thus, the average yield of onion per hectare in this demonstration trial was 125 quintal per hectare and the prevailing market price at the harvest was 3000 Ethiopian birr per quintal. The mean income from the sale of Nafis bulb yield was 375,000 Ethiopian birr per hectare. The profit of improved onion production in this case is the difference between the mean income of 375,000 Ethiopian birr per hectare and the total cost of onion production of 40075 Ethiopian birr per hectare. Thus, the profit is 334,925 Ethiopian birr per hectare and it implies that each household who engaged in improved onion production would get a profit of 334,925 Ethiopian birr per hectare. The benefit-cost ratio of onion production per hectare was calculated to see the importance of onion production in

Table 3. Agro-pastoral perception on improved and local onion varieties.

	Improved			**Local**		
Traits	Scores	Weights	Scores*Weights	Scores	Weights	Scores*Weights
Disease resistance	2	1	2	1	1	1
Insect pest resistance	2	2	4	1	2	2
Bulb size	2	4	8	0	4	0
Bulb yield	2	5	10	0	5	0
Marketability	2	3	6	0	3	0
Sum of (Scores*weights)			30			3
Rank			1			2

Note: Scores = (0 = Low 1 = Medium 2 = High) & Weight = (5 = Bulb yield 4 = Bulb size 3 = Marketability 2 = Insect pest resistance 1 = Disease resistance.

the area relative to the cost of production. The benefit-to-cost ratio of improved onion production was 8.34:1. This indicates that the benefits outweigh the costs, suggesting a positive return on improved onion production in the area. The benefit-cost ratio is useful in decision-making as it helps to assess whether onion production in the area is financially viable or not. Moreover, the benefit-to-cost ratio of improved onion production demonstrates that each household gets a benefit from onion production eight times the cost of production. This result would encourage new agro-pastoralists to start with onion production and area expansion to evaluate the costs and benefits of these profitable initiatives. This result is in agreement with the findings of Beshir & Nishikawa [14] and Koye et al. [5] who found the highest return from the production of improved onion variety (Nafis) as compared with the local variety.

3.4 Challenges in Onion Production in the Study Area

The challenging factors of onion production in the research site are presented in Table 5. As mentioned by agro-pastorals, the lack of onion seed is a serious problem for onion production. Improved onion seed varieties are often developed to possess desirable traits such as higher yield potential, disease resistance, and improved quality. Without access to these improved seeds, farmers or agro-pastorals may experience lower crop yields, affecting their livelihoods and food production [13,15]. Storage problems in onion production can arise due to various factors such as physical damage, lack of proper curing etc. Onions require proper curing and storage conditions to maintain their quality and extend their shelf life [1]. However, in the study area maintaining ideal humidity and temperature levels to prevent spoilage and sprouting can be challenging, especially lacking appropriate storage facilities. This problem is ranked as the second most challenging factor in the area. In the research site, agro-pastorals produce onion using a water pump for irrigation and it needs regular maintenance and timely repairs. However, the lack of skills in the maintenance of water pumps challenged onion production and ranked as third level as the smooth operation of water pumps in onion production is critical. Lack of irrigation water pump is the main challenging factor in onion production [7,6]. Agro-pastorals often face challenges in establishing direct connections with potential buyers and distributors. This can result in reliance on intermediaries, leading to lower profits and agro-pastorals ranked this problem as the fourth challenge in the research site. Lastly, they reported that seed preparation skills are another issue and need further. A well-prepared seedbed provides controlled conditions such as moisture, temperature, and protection from pests or diseases [16]. They allow for easier management of seedlings and facilitate proper root development before transplanting.

3.5 Lessons Learnt and Ways Forward

Onion production in agro-pastoral areas can be a rewarding venture and requires careful planning and management to achieve success. As it stands, the pastoral and agro-pastoral research and extension group established in

Table 4. Economic returns and costs of onion production.

Cost items per ha	Unit	Quantity	Unit cost (ETB)	Total cost (ETB)
Improved seed	kg	4	1500	4*1500 = 6000
NPSB	kg	100	25	100*25 = 2500
Urea	kg	150	22.5	150*22.5 = 3375
Karate @5%)	Liter	2.5	1200	2.5*1200 = 3000
Mancozeb 80% wp	kg	2	900	2*900 = 1800
Land preparation	Tractor rent per day	2	2500	2*2500 = 5000
Transplanting	Labor per day	40	100	40*100 = 4000
Weeding and chemical application	Labor per day	40	100	40*100 = 4000
Irrigation water application	Round/month/labor	9*3*2	100	9*3*2*100 = 5400
Harvesting	Labor per day	30	100	30*100 = 3000
Total variable cost				38075
Fixed cost				2000
Total cost				40075
Benefits (birr/ha)				
Bulb yield (Q/ha)	Quintal	125	3000	125*3000 = 375,000
Profit (birr/ha)				334,925
Benefit-cost ratio				334,925/40075 = 8.34:1

Table 5. The main challenges of onion production in the area.

Challenges of onion production	Extent of challenges on onion production					
	Low	Medium	High	Score	Index	Rank
Storage problem	3	6	16	38	0.187	2
Lack of hybrid seed of onion	2	9	14	37	0.182	1
Lack of market linkage and inaccessibility	4	8	13	34	0.167	4
Lack of seed beds	4	9	12	33	0.162	5
Water pump problem	5	4	16	36	0.177	3

Note: The values represent the extent of challenges: Low = 0, Medium = 1, High = 2.

the area hardly ever engaged in onion production.

However the formations of PAPREGs make them work together and learn from each other. This helped the PAPREGs members to undertake all the crop management activities.

This made it easier for the pastoral and agro-pastoral research and extension group members to carry out all of the onion production management. The competition among the participants to showcase their individual performances. So, the formation of the pastoral and agro-pastoral research and extension group is an essential task for technology adoption in the area.

4. Conclusions and Recommendations

The promotion of improved onion (Nafis variety) with proper agronomic management resulted in a higher bulb yield. Thus, it had shown 78.6% yield increments over the local onion production in the area by agro-pastoral field management. Moreover, the host agro-pastoralist preferred this variety its market preference. Additionally, agro-pastoralists have the highest financial returns from this onion production. Thus, it is advisable to use this improved onion variety (Nafis) with its proper agronomic management practice to enhance the production and productivity thereby improving the livelihoods of agro-pastorals in the study area. Further, it needs adequate support of inputs such as onion seed (Nafis), fertilizer, agro-chemicals, easy water lifting devices and agricultural mechanization technologies from respective stakeholders for sustainable production to improve household income for agro-pastorals in the area.

Author Contributions

Awoke Tadesse developed a proposal, conducted the field experiment, recorded all field data, and wrote the paper. Asmera Adicha was involved in data collection and wrote the paper. Atlaw Eshbel, Yibrah Gebre Meskel and Anteneh Tadesse participated in the field experiment and monitored the field activity.

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Data Availability

The data used for this field experiment were included in the main text and the corresponding author will avail the necessary data upon request.

Conflicts of Interest

The authors disclosed no conflicts of interest.

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