EFFECT OF ECO-GREEN ORGANIC LIQUID FERTILIZER AND VARIETY ON GROWTH AND YIELD OF ONION (*Allium cepa* L.) IN DEBRE-LIBANOS DISTRICT, NORTH SHOA, ETHIOPIA

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Effect of Eco-green Organic Liquid Fertilizer and Variety on Growth and Yield of Onion (*Allium cepa* L.) in Debere-Libanos District, North Shoa, Ethiopia

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SCHOOL OF GRADUATE STUDIES

I hereby certify that I have read and evaluated this Thesis entitled, Effect of Eco-green Organic Liquid Fertilizer and Variety on Growth and Yield of Onion (*Allium cepa* L.) in Debere-Libanos District, North Shoa, Ethiopia prepared under my guidance by Abayu Emyew Doyo. I recommend that it be submitted as fulfilling the thesis requirement.

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As a member of the Board of Examiners of the Degree of Master of Science Thesis open Defense Examination, I certify that I have read and evaluated the thesis prepared by Abayu Emyew Doyo and examined the candidate. I recommend that the thesis be accepted as fulfilling the thesis requirements for the degree of Master's in Horticulture

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BIBLIOGRAPHICAL SKETCH

Abayu Emew Doyo was born in March 1967 at Silme peasant association, North Shoa zone, located 133 km North of Addis Ababa. He started his primary education at Silme Elementary School in 1972 E.C. He attended his secondary school at Fitche Comprehensive Secondary School from 1978 to 1982. He joined Awassa College of Agriculture, Department of Plant Science in 1983 and completed his Diploma in October 1985. He further continued his BSc study at Haramaya University, College of Agriculture and Rural Development and graduated in September 2008. He was employed at Kembata and Hadiya Aweraja, Konteb District, Fugaja Development Centre in the position of Development Agent under the Ministry of Agriculture and served for 3 consecutive years, and he was promoted to the position of District Agronomist. In 1991, he came to Adami-Tulu Jido Kombolcha District and worked for 12 years at different positions from Extension Agronomist up to District Deputy Head Office of Agriculture. Then, he came to North Shoa Zone, Girar Jarso District in 2001 and has been serving at different positions (from District Deputy Head Office of Agriculture up to cluster coordinator under Agricultural Transformation Agency at the zonal level. Mr. Abayu joined Salale University in 2020 E.C. to pursue his MSc. degree in Horticulture. Finally, he needs to work as a consultant in crop science to contribute to smallholder farmers for the future.

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ACRONYMS AND ABBREVIATIONS

ANOVA	Analysis of Variance
CAGR	Compound Annual Growth Rate
CAGR	Compound Annual Growth Rate
CEC	Cation Exchange Capacity
CIMMYT	International Maize and Wheat Improvement Centre
C: N	Carbon to Nitrogen Ratio
CSA	Central Statistical Agency
CSSE	Crop Science Society of Ethiopia
CV	Coefficient of Variance
DGC	Decision of the Department Graduate Council
DTPA	Di-ethylene tri-amine-penta-acetic acid
EARO	Ethiopian Agricultural Research Organization
EC	Electrical Conductivity
EG	Eco-Green
EGOLF	Eco-Green Organic Liquid Fertilizer
ETB	Ethiopian Birr
FAO	Food and Agricultural Organisation
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
GIZ	Germen International Cooperation for Development
IAA	Indol Acetic Acid
ICPOES	Inductively Coupled Plasma Optical Emission Spectroscopy
IJEAB	International Journal of Environment, Agriculture and Biotechnology
IOF	In Organic Fertilizer
LSD	List Significant Difference
MARC	Melkasa Agricultural Research Centre
MMR	Marginal Rate of Return
MoANR	Ministry of Agriculture and Natural Resource
NPSB	Nitrogen, Phosphorous, Sulphur and Boron Containing Fertilizer
OLF	Organic Liquid Fertilizer
OPV	Open Pollinated Variety

ACRONYMS AND ABBREVIATIONS (*Continued)*

PH	Measure of Acidity
PLC	Private Limited Company
RCBD	Randomized Complete Block Design
RST	Relief Society of Tigray
UNDP	United Nations Development Program
USA	United States of America
WHO	World Health Organization

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ABSTRACT

Onion is among the commercially cultivated and profitable horticultural businesses in the study area and the world. But, its growth and yield performances are highly dependent on the nutrients to be applied and the variety to be used. Thus, a field experiment was conducted to evaluate the effect of organic liquid fertilizer and variety on growth, yield components and yield of onion laid out in RCBD with 3 replications during the 2022 cropping season under irrigation at Debre-Libanos district, north Shoa zone, Ethiopia. Factorial combination of 5 levels of fertilizer (0 lit EGOLF ha^{-1}, 200 NPSB+150 Urea kg ha^{-1}, 200 lit EGOLF ha^{-1}, 400 lit EGOLF ha^{-1}, 600 lit EGOLF ha^{-1}) and 3 levels of variety (Robaf, Nafis, and Nasik) were used as study treatments. Crop phenology, growth, yield component and yield data were collected and analysed using R software. Means of the studied parameters were separated by using the least significant difference test at a $P < 0.05$ level of significance. Correlation relations between pairs of parameters were also computed. The result revealed that the maximum (36.53 t ha^{-1}) bulb yield of onion was obtained from 200 lit ha^{-1} of EGOLF, while the minimum (15.36 t ha^{-1}) was obtained from the 0 t ha^{-1} (control) treatment. Nafis was the highest yielder, but Robaf was the most economically feasible variety among the others. The marginal rate of return obtained 12155.62% for Robaf variety treated with 200 lit ha^{-1} of EGOLF was above the minimum acceptable marginal rate of return. From the result obtained, we can conclude that the EGOLF application can increase productivity by more than 137.82% over the control at the rate of 200 lit ha^{-1}. Accordingly, the application of 200 lit ha^{-1} EGOLF to Robaf variety was the best recommendation as it returned with 12155.62% MRR. However, this study was conducted at one place for a single season and has to be conducted in multiple locations across similar agroecologies for sound recommendations beyond the present study.

Keywords: EGOLF, onion, variety, yield

1. INTRODUCTION

Onion (*Allium cepa* L.) is the most widely cultivated horticultural crop of the genus Allium and family Alliaceae (Dawar, 2007; Kumar, 2014). It is an herbaceous biennial grown primarily for its edible bulb. It is one of the most important crops cultivated commercially in most parts of the world (Kondal, 2014). It is a widely cultivated important vegetable crop that is a complementary product to tomatoes and has global commercial importance (Cyna, 2020). It is a vegetable bulb crop known to most cultures and consumed worldwide (FAO, 2012); thus, it is commonly known as "Queen of the kitchen" (Griffiths *et al.,* 2002). Due to its highly valued flavour and the ability to enhance the flavour of other foods, aroma, unique taste, and the medicinal properties of its compounds (Kapoulas and Koukounaras, 2017). It is consumed universally almost daily in many homes primarily as a seasoning for flavouring dishes. Fresh onion has about 86.6% moisture, 11.6% carbohydrate including soluble sugars, 1.2% protein, 0.1% fat, 0.2-0.5% Ca (calcium), 0.05% P (phosphorus), traces of Al (aluminium), Cu (copper), Fe (iron), Mn (manganese), Zn (zinc) and vitamin A, B and C (Sara *et al*., 2015). It has nutritional value that helps alkaline reaction in our body and is important in neutralizing the acidic substance produced during the digestion of meat, cheese, and other foods (Yousuf *et al*., 2013).

The chemical flavonoids, anthocyanins, fructooligosaccharides and organosulphur compounds found in the onion are considered medicinal and have health benefits to fight different diseases, including cancer, heart and diabetic diseases (Goldman, 2011; Pradeep and Srinivasan, 2018). Flavonoids and anthocyanins, which are secondary metabolites, are responsible for the attractive colour of leaves, fruits and flowers. In the last few decades, these phytochemicals have attracted the attention of health professionals mainly because of their antioxidant properties, aromatic spice and food supplement. Onions are also a valuable source of vitamins, minerals, health-promoting substances and essential oils (Bang and Kim, 2010; Tasleem *et al*., 2010; Dossa *et al*., 2018; Ongkowijoyo *et al*., 2018). The best described property of these compounds is the antioxidant capability towards free radicals that are produced by cells metabolism or in response to exogenous environmental factors (Leopoldini *et al*., 2011).

Onions are hardy, cool season vegetables that grow best at temperatures of 12 to 24 °C, growing particularly well in areas with cool spring weather and drier, hotter summer weather; and they require a fertile, well-draining soil such as clay or silt loams with optimum pH ranges between 5.5 and 6.5, and 6.0-8.0 is preferred for onion production (Nikus and Fikre, 2010). The plants do not do well in acidic soils (below pH 6.5). It should be set out in full sun for optimum bulb development. Onions are biennial vegetables and if they are left in the ground for a second year, they will produce flowers and seed. (Lemma and Shimeles, 2003).

Onion can be cultivated twice per year, both under irrigation and rain-fed conditions in different parts of Ethiopia (Belay *et al*., 2015). However, it is largely produced by smallholder farmers and a few commercial growers, mainly under irrigation, and a lower share using rain. It provides business options from seed, dry bulb, and seedling production. It has a lower risk of overproduction than most other vegetables because it can withstand the rough handling from field harvesting to final delivery to consumers. Moreover, onion dry bulb can be stored for 2–3 months when properly cured (Selamawit *et al*., 2013).

Maintaining an adequate level of soil fertility has been seen as one of the best management practices that influence soil fertility, plant growth, development, yield and quality of crops (Amare, Melkamu, 2020). Thus, application of fertilizers is recommended to supplement the already existing nutrients in the soil (Sisay and Sisay, 2019). Organic fertilizers are among the different forms of fertilizers, which are prepared either in solid or liquid form. Compost, vermicompost, and different forms of manures are the solid form; whereas EGOLF, compost extracts, vermicompost extracts, and food stillages are the liquid forms of organic fertilizers applied via root systems as well as via foliar or both (Confora *et al*., 2015; Kim *et al*., 2015; Jayasundara *et al*., 2016).

One of the sources of liquid organic fertilizers is the organic wastes of traditional markets (Hendarto *et al.,* 2018), with an abundant amount and that is available in all regions of peri-urban as well as urban areas. These facts suggest, no doubt, that the continual availability of traditional markets' organic wastes always exists; therefore, every time the community needs them, they are available at all times. The conversion of traditional market wastes into liquid organic fertilizer shows that there is a hope of change from pollution potential into expectation potential of the organic market wastes, in order to support the sustainability of human existence and life (Hendarto *et al.,* 2019).

Eco green liquid organic fertilizer contains animal and plant extracts and it is especially useful as a foliar spray, and the plant can absorb nutrients through comprising leaves, stems, inflorescences and fruits (Pandey *et al.,* 2013). This delivery method provides a wide array of plant nutrients, chelating agents, and plant hormones. It has been scientifically proven to be effective in numerous commercial agriculture environments and has its positive traits due to its low chemical-added materials (Hendarto *et al.,* 2019).

Liquid fertilizers contain macro and micro nutrients including N (nitrogen), P (phosphorus), K (potassium), Ca (calcium), S (sulphur), Fe (iron), Mn (manganese), Na (sodium), B (boron), Cl (chlorine), Ni (nickel), Cu (copper), Zn (zinc), Mo (molybdenum), C (carbon) and others (Kariada, 2014). Bio substances grow like gibberellin, cytokinin, auxin (BBSDLP, 2008) and the performance of plants can be observed from their aspects of growth, fresh matter production, and the contents of their nutrients (Bhilave *et al.*, 2013). The Sri Lankan Government has launched a national program named "one million of prosperous home gardens" in April 2020 during the global COVID-19 Virus pandemic conditions because of prevalence of kidney disease in the major parts of the country discourage farmers to use synthetic agrochemicals in agriculture (Weeraratna, 2013) which strength the home garden concept of utilization of organic fertilizer on vegetables, fruits and cereals due to higher nutrient contents (Suthar and Singh, 2008; Sisay and sisay, 2019).

Moreover, studies on the importance, amount, time of application, and method of application of liquid organic fertilizers are not widely adopted in our country. Even if the EGOLF Producing PLC, as a company founded in 2007, is a research centre, and began production of organic liquid fertiliser on 20 October 2018, in Arsi, Oromia Regional State, in a ceremony organised by EGOLF (www.ehpea.org, www.globalagriculture.org, www.agriculture.com).

Although there is a potential and demand to produce and to consume onion bulbs in the study area, respectively, farmers are producing shallots in a traditional way and onions is not producing significantly even in a traditional way; thus, their bulbs are brought in from other areas of outside the zone. On the other hand, farmers in the study area are not using any types of fertilizer for vegetable crop production, but maintenance of high crop yield under intensive cultivation is possible only through the use of fertilizers. Inorganic fertilizers are not usually available in the required amount and timely supply; rather, they are expensive for the low-income small-scale farmers since they are an import commodity. It claims environmental and health issues that deteriorate soil, soil organic matter, soil fertility, and increase soil acidity, reduction of biodiversity, contamination of groundwater, and a problem of health (Krasilnikov *et al*., 2022). Their cost is increasing year to year, and the value of the country's currency is fluctuating from time to time to import the required amount and access to the end users at the right time, besides their unaffordability by smallholder farmers (https://addisstandard.com/analysis-farmers-brace-for-the-worst-as-fertilizer-prices-rise).

Organic liquid fertilizer can be used as an alternative to inorganic fertilizer (Turan *et al.,* 2022), leading to higher crop yields, even better than the yield of inorganic fertilizer (Eadwards *et al.,* 2007). It has no adverse side effects, improving both the physical and biochemical properties of the soil (Menale *et al*., 2009). It will also have the potential to save the country foreign currency it spends on importing fertilizer.

Another constraint in onion production is the lack of improved varieties (Lemma and Shimelis, 2003) that are well adapted to different agroecologies. Onion varieties also differ in size, colour of skin, pungency, and maturation *etc.* of bulbs (Yoo *et al.,* 2006). Large-sized bulbs are mild in pungency and are sweet compared to small-sized onions. Red coloured cultivars are more pungent than other coloured cultivars and have high demand in the market (Lemma and Shimelis, 2003). Farmers in the study area do not have access to an improved onion variety, and the lack of introduction of an appropriate variety/cultivar is also another bottleneck of the area.

So, studies on the effect of different rates of EGOLF on growth, yield components and yields of onion varieties can show a clue to determine the economical and optimal rate of production and identify the best performing improved variety or varieties of onion in the study area with the following objectives:
To study the effect of different rates of EGOLF and variety on growth, yield components and yields of onion (*Allium cepa* L.) in Debere Libanos district, north Shoa zone, Oromia, Ethiopia.

- To evaluate the effect of the EGOLF rate on growth, yield components and yields of onion varieties.

- To identify the best-performing improved onion variety for the study area

- To determine the economically optimal rate of EGOLF for onion production in the study area.

2. LITERATURE REVIEW

2.1. Botanical Description of the Onion

Onion (*Allium cepa* L.) is the most widely cultivated species of the genus Allium of the family Alliaceae (Dawar, 2007; Kumar, 2014). It has been classified in hierarchical level as follows: Kingdom: Plantae, Subkingdom: Tracheobionta, Super division: Spermatophyta, Division: Liliopodia, Subclass: Liliales, Order: Liliaceae, Genus: Allium Species: Allium cepa L. Onion belongs to the family Amaryllidaceae; the plant is either biannual or perennial (depending on the cultivar) and smells when crushed and grown for its edible bulb. (WHO, 1999). It is a Monocot plant; its seed germinates epigeally, implying that the cotyledons are pushed above ground. The hypocotyl elongates while the epicotyl remains in the same place where the Seed was first placed. Cotyledons emerge above the soil surface by elongation of the hypocotyl and generally become green. The radicle comes up and bends down to the earth. The development of the plumule to form a shoot is delayed a bit (Anish and Snehashis, 2020) and the stem of the plant is a flattened disc at the base and the tubular leaves form a pseudo stem where their sheaths overlap. The leaves are either erect or oblique and there are 3–8 per plant. The onion plant produces pink or white flowers clustered on stalks. The bulbs are formed just above the flattened stem of the plant by overlapping leaves. The bulb is made up of several layers, each corresponding to a leaf. They are generally oval, but their shape can be variable and occur in clusters of 3–18 to a plant. The bulb is protected by a membrane that turns to a papery coat. Onion plants can reach a height of 50 cm and are grown as annuals, harvested after one growing season. Onion may also be referred to by cultivar and these include red or purple onion (https://plantvillage.psu.edu/topics/onion/infos).

Most commercially cultivated onions are grown from the plant's small black seeds can be direct seeded as soon as the soil is workable on the field or seedling can be prepared on the nursery seed bed for transplanting based on Lemma and Shimeles, 2003. The planting site should be cultivated deeply and be free of stones. Work some compost or farm yard manure into the soil and ensure that soil has a soft crumbly texture before planting. Seeds should be sown 2.5 cm deep allowing 10 cm between row on 20 cm raised seed bed or directly sown on the field on a single row having 20 cm distance between row and the germinated plant should be thinned with a distance between plant to 10 cm in a rain fed area or 40cm x 20cm x 20cm on irrigation area in double row (Selamawit *et al.*, 2013).

Seedlings should be planted on the ridge at 20 cm distance, having a 40 cm furrow for irrigation. The distance between plants will be 10 cm, but can be improved (increased or decreased a few centimetres by considering the soil type and fertility, water availability, climatic conditions, variety and other relevant factors. Transplanting should be done when the seedling reaches 3-4 leaves or 13-15 cm height (Lemma and Shimeles, 2003).

The planting field should be watered before planting; then it should be watered thoroughly after planting and once every week thereafter; depending on the climatic condition, water quality should be assessed before growing any transplants, but onions grow best when the water source has a pH range of 5.5 to 7.0 with a low EC or salt level (https://extension.psu.edu onion-transplant-production). Moisture management is critical in growing high-quality onion transplants. Overwatering can lead to damping off, poor root growth, or disease development. Care should be taken not to allow the soil to become dry and cracked, as onions have a shallow root system and this indicates a lack of water. Timely weed control is very important to avoid competition for water, nutrients, and sunlight. Onion is a heavy feeder, and needs application of fertilizer based on the recommended rate and proper application methods and time (https://plantvillage.psu.edu/topics/onion/infos).

2.2. Origin and Distribution of Onion

Onion is originally from central Asia between Turkmenistan and Afghanistan, where some of its relatives still grow as wild plants (Zohary and Hopf, 2000; Kondal, 2011). South-western Asia is the centre of domestication and variability, from where it was spread first across the world and has been cultivated for over 4700 years as annuals for bulb production purposes (Brewster, 2008). It is a crop that is classified as a cool-season crop. However, it can be grown in a wide range of climatic conditions. It is mainly grown for its bulbs, although the green shoots of salad onions are also consumed. Onion bulb is used in every home, almost daily, across Ethiopia (AgroBIG, 2016). The crop is grown in more than 175 countries in the world, among which China and India are the largest producers, followed by the USA, the Netherlands, Egypt and Iran (FAOSTAT, 2014; Kulkarni *et al.*, 2014; Manna, 2014). Onion has been valued as a food and a medicinal plant since ancient times. It is widely cultivated, second only to tomato, and is a vegetable bulb crop known to most cultures and consumed worldwide (FAO, 2012).

Onion is valued for its aromatic spice and food supplement distinct pungency or mild-flavoured form of essential ingredients of many dishes, but they are also a valuable source of vitamins, minerals, health-promoting substances and essential oils (Dossa *et al*., 2018). It is consumed universally almost daily in many homes, primarily as a seasoning for flavouring dishes. Fresh onion has about 86.6% moisture, 11.6% carbohydrate including soluble sugars, 1.2%protein, 0.1% fat, 0.2-0.5% Ca(calcium), 0.05% P(phosphorus), traces of Al(aluminium), Cu (copper), Fe (iron), Mn (manganese), Zn (zinc) and vitamin A, B and C (Sara *et. al*., 2015). It has nutritional value that helps alkaline reaction in our body and is important in neutralizing the acidic substance produced during the digestion of meat, cheese and other foods (Yousuf *et al*., 2013).

The chemical flavonoids, anthocyanins, fructooligosaccharides, and organosulphur compounds found in the onion are considered to have medicinal and health benefits to fight different diseases, including cancer, heart and diabetic diseases (Goldman, 2011; Pradeep and Srinivasan, 2018; Zhan *et al*., 2021). Flavonoids and anthocyanins, which are secondary metabolites, are responsible for the attractive colour of leaves, fruits and flowers. In the last few decades, these phytochemicals have attracted the attention of health professionals mainly because of their antioxidant properties (Bang and Kim, 2010; Tasleem *et al*., 2010; Ongkowijoyo *et al*., 2018). The best described property of these compounds is the antioxidant capability towards free radicals that are produced by cells' metabolism or in response to exogenous environmental factors (Leopoldini *et al*., 2011).

2.3. Onion Production and Productivity in the Globe and Ethiopia

Onion is largely produced in developed nations and has dominated in the international markets due to its higher quality production and longer storage life (Opara, 2003). According to FAOSTAT (2021) onions worldwide cultivated over 5,192,651 hectares and production of 99,968,016 tons per annum (https://www.atlasbig.com), out of this China and India takes the highest share respectively. China and India both produced more than 50 billion pounds of onions in 2019 (FAO STAT, 2019). Egypt is the leading country in Africa, by producing 22.08 million tons of onion per year for domestic and international markets that rank as the third of the world (Kulkarni *et al*., 2014). With regards to its global consumption, Libyans are the one who consumes the highest amount of onion, which accounts for an average of 30 kg annually per capita, followed by the Americans (16 kg) (FAO, 2015).

Ethiopia is the third-biggest producer of onions on the African continent, next to Egypt and South Africa; it contributes only 2.7% to the total world production between 2000 and 2011 (FAOSTAT, 2019). Averaged from 2010 to 2018, the onion area harvested, production, and yield at the national level are 28,942 hectares, 33,947 tons and 11.70 tons ha^{-1}, respectively (CSA, 2019; FAOSTAT, 2019), which is far below the world average of 19.7 tons ha^{-1} (Megersa, 2017). In Ethiopia, the total area under onion production was about 38,952.58 ha, of which 3,460,480.88 tons were produced in 2020/2021, with an average yield of about 8.8 t ha^{-1} (CSA, 2021). This showed that the production of onions in Ethiopia (8.8 t ha^{-1}) is significantly under the global average (Habtamu, 2017). Production of onions can be constrained by the inaccessibility of quality planting materials organized with other cultural practices (CSA, 2021).

Onion is the top-most important vegetable crop produced almost in all parts of the country by smallholder farmers due to its requirements in the daily diet of people and as a source of livelihood for most people and for export market purposes (Maru and Gibramu, 2014). It has grown mainly for its bulbs, even if the green shoots are used for salads as well as in the form of several processed products (Teshika *et al*., 2018).

Its production history in Ethiopia stretches back to the 1970s (Muluneh *et al*., 2019) when foreigners brought the planting material from Sudan and then distributed it to different parts of the country since its intensive production has been started. Later on, the improved cultivars were released by Melkassa agricultural research centre which has been incorporated into the farming system of the country and now has become important vegetable crop for markets and in a daily life of people of the country (Nikus and Fikre, 2010) and cultivated as a warm-season vegetable crops in Ethiopia.

Onion can be cultivated twice per year, both under irrigation and rain-fed conditions, in different parts of the country (Belay *et al*., 2015). However, it is largely produced by smallholder farmers and a few commercial growers, mainly under irrigation and lower share using rain. It provides business options from seed, dry bulb, and seedling production. It has a lower risk of overproduction than most other vegetables because it can withstand the rough handling from field harvesting to final delivery to consumers. Moreover, onion dry bulb can be stored for 2–3 months when properly cured (Selamawit *et al*., 2013).

Onion ranked second in production of all vegetable crops next to Tomato, which has been concentrated in the central rift valley of the country, particularly in the upper Awash and Lake Ziway areas (Mengistu *et al.*, 2009). It is currently becoming a popular crop despite its recent introduction to the country because of its yield potential per unit area, the ease of propagation method both by seed and bulb, and the presence of high domestic and export markets (Asfaw and Eshetu, 2015).

In Ethiopia, onions are planted on 36.4 million hectares with a total production of 273,859 tons. The total production and the total cultivated area for onion grew by 18.7% and 59.7%, respectively, between 2015 and 2020. The productivity of onion, however, declined by 25.7 percent over the same production period (CSA, 2020). Hence, (Nikus and Fikre, 2010) also elaborated that the area under onion production is an increasing trend from time to time, mainly due to the merit of production and ease of marketing. However, the productivity of onion in the country is much lower than that of other African countries, with an average value of 11.70 tons ha^{-1} in Ethiopia and the world average is 19.7 t/ha (CSA, 2019; FAOSTAT, 2019) despite its year-round production scenarios (FAO, 2012). These low yield results indicate that the presence of a huge gap in production and productivity at the country level because to the absence of improved cultivars, application of inappropriate agronomic practices and limited attention/awareness on the benefits of intensive production. Even though, (Samuel, 2013) pointed out as recently a little production progress has been observed after a government has reaffirmed its commitments to the agricultural sector in plan to scaling up the best practices by bringing up of the productivity of most average farmers, expansion of irrigation developments and production of high-value crops in suitable areas including onion for smallholder farmers. Therefore, according to (CSA, 2020/21), the trends of onion production status are fluctuating. The production status has been boosted to the highest annual production growth rate (40%) for the year.

Eco green is an organic liquid fertilizer produced by EGOLF Producing PLC Company, founded in 2007 by Kebede Lakew, winner of the 2015 UNDP Entrepreneur of the Year Award, as a research centre. Began production of organic liquid fertilizer in October 2018, after more than eight years of research. It collects and buys organic west from nearby farmers and transforms them in to liquid fertilizer through a fermentation process (www.ehpea.org, www.globalagriculture.org). It can be used both in foliar application, including with overhead sprinkler, pump sprayers, tractor sprayers, drenching through drip irrigation, or spill to the root zone, especially for vegetables, fruits, and for raised seedlings by making the soil moist during application for its effectiveness.

2.4. Challenges of Onion Production in Ethiopia

Agriculture in Ethiopia is practiced in an open environment and liable to different biotic and abiotic factors like insect, disease, weed and different environmental factors, weak extension delivery system, inappropriate agronomic management like plant nutrient management, spacing, shortage of quality seed and well-adaptable improved seed supply, limited use of improved seeds and fertilizers, pest and disease control poor irrigation systems used by small holder farmers, high costs of agricultural chemicals including fungicides, insecticides and fertilizers are the main bottlenecks (Currah and Proctor, 1990; Samuel, 2013; Melkamu *et al.,* 2015; AgroBIG, 2016; Yemane *et al*., 2016; Addisu, 2017; Habtamu, 2017; Taye, *et al*., 2018; Muluneh *et al,* 2019; Kebede *et al*., 2022). Continuous use of inorganic fertilizers without supplementation with organic fertilizer has often resulted in micronutrient deficiencies, imbalance of soil physical and chemical properties and unsustainable crop production (Gupta *et al.,* 1999; Yohannes *et al*., 2017).

The local shallot produced by farmers is highly multiplied by its bulb, which is highly attacked by root and bulb root diseases and easily transmitted from place to place throughout the country and in poor marketable output. In the present, saturated agricultural research centres have developed a seed planting material, but its awareness creation extension is not rapid to address the users (Atman *et al.*, 2021).

Moreover, quality and yield of particular onion variety greatly affected by planting density even if grown in the same environment (Saud *et al.,* 2013; FAO, 2017; CSA, 2018). Lack of storage to increase its shelf life; poor handling of the products, imperfect price information, lack of horizontal coordination among producers, weak market linkage (lack of vertical coordination among chain actors), lack of improved seed producing and distributing organization and lack of quality standards and grades are the major constraints for the marketing process of onion in Ethiopia (Teklebrhan *et al.*, 2020).

2.5. Factors Affecting the Growth and Yield of Onion

2.5.1. Growth and yield of onion as influenced by variety.

The diverse agroclimatic conditions of Ethiopia and its immense potential to cultivate vegetable crops at small as well as large commercial scale provide the opportunity of producing onion bulbs, seeds and cut flowers for local use and export market (CSSE, 2006; Gebremedhn, 2018). The country has high potential to benefit from onion production, and the demand for onion is increasing from time to time for its high bulb yields, seed and flower production potential (Lemma and Shimeles, 2003).

Several constraints cause low productivity of onions in the country. Lack of improved varieties is one of the influencing factors (Lemma and Shimeles, 2003). Growth of onion is influenced by leaf number per hill, leaf length, leaf width, and plant height. Yield is also affected by bulb length, bulb diameter, bulb weight and marketable produce. Onion is weaker than most other crop plants in extracting nutrients from the soil, especially the immobile types, because of their shallow and unbranched root system. A cultivar may perform differently under diverse agroclimatic conditions and various cultivars of the same species grown even at the same environment with different management often yield differently due to the genetic makeup of the cultivars and the interaction effects of genotype with environment or genotype with management (Tegbew, 2011; Yemane *et al*., 2013). As Gautam *et al*. (2006) indicated, the yield of fresh onion bulb is significantly affected by varieties which agrees with findings of Rajcumar (1997), Jilani (2004) and Geremew *et al*. (2010), and also reported significant differences within varieties for marketable bulb yield.

Premature bolting, bulb splitting, lower yielder, and poor adaptation of varieties are among the many production constraints. So, identifying adaptable and best-performing improved onion variety is very important for the study area to improve the yield of onion. The major constraints of bulb production are premature bolting, bulb splitting, and poor adaptation of varieties to low input management. (Budathoki and Bhattarai, 1994) (https://doi.org/10.17660/ActaHortic.1994.35 8.54).

2.5.2. Growth and yield of onion as influenced by fertilizer.

Organic and inorganic fertilizers and improved agronomic management an important practices to reduce the yield gap and to enhance the food security within an area and among farming households (Fanadzo *et al.,* 2011; Kihara *et al.,* 2015). Onion, compared with most crops, is usually the weakest crop plant in terms of extracting nutrients, especially the immobile types, because of their shallow and unbranched root system; hence, it requires and often responds well to the addition of fertilizers (Brewster, 1994; Rizk *et al*., 2012). Thus, the crop is a heavy feeder, requiring ample supplies of N; hence, it requires and often responds well to the addition of fertilizers. However, excess application of nitrogen causes excessive vegetative growth, delayed maturity, increased susceptibility to diseases, reduces dry matter contents and storability and ultimately reduces yield and quality of bulbs (Brewster, 1994; Guesh, 2015).

Organic fertilizers are those fertilizers manufactured using organic substances which are easily biodegradable, naturally occurring and have nutrient-enhanced soil fertility and plant growth (Bokhtiar *et al*., 2005). These substances are further decomposed and broken into smaller and soluble particles by numerous microorganisms. After being turned into soluble and simpler compounds, these fertilizers are taken in by the plant. Manure, slurry, worm castings, peat, seaweed, sewage, and guano are the naturally occurring ones: green manure and compost, blood meal, bone meal and seaweed extracts, and others are manufactured organic fertilizers (Wakui, 2009; Burnett *et al*., 2016). Organic liquid fertilizers are short-acting. Consequently, they are easier to regulate than dry organic ones, which are longer-acting. The ease with which liquid fertilizers can be used makes them quite popular and therefore a sustainable fertilizer (https://www.bioenergyconsult.comliquig-organic).

The newly sourced artificial fertilizer has short-term benefits, but it has severe long-term side effects, such as soil toxicity and decline in soil fertility. Afterward, the idea of organic farming was acceptable to a developed organic agriculture system (Assefa and Tadesse, 2019).
While inorganic fertilizers are those fertilizers that are constituted by inorganic chemical substances, *i.e*., granular triple superphosphate, potassium chloride, urea, anhydrous ammonia, *etc*. These fertilizers are usually non-biodegradable. These fertilizers are also called artificial or synthesized fertilizers as they are manufactured in factories using the latest technologies (Liu *et al*., 2007). Artificial and inorganic fertilizers have certain disadvantages,

as they have to be applied again and again. They become a necessity to the soil, or else the productivity is hampered. They act as a drug for the soils, as till the time the soils are fertilized, they remain productive, or else they die down. Eutrophication, nutrient pollution is caused due to the excessive application of artificial fertilizers (Bokhtiar *et al*., 2005; Kaur *et al*., 2005).

Today, what each farmer is looking forward to is a proper solution to the agricultural problems without the negotiation of the yields. It is a universally acknowledged fact that organic fertilization methods are more environmentally friendly and fetch slower but steadier results. Today, when the world is advancing so fast in every aspect, organic fertilizers are one of the greatest innovations of the agricultural revolution (Goutam, 2016).

The increasing demand for organic food is becoming more popular globally, which leads to organic farming and the utilization of organic fertilizer. It is a production system that avoids or largely excludes the use of synthetic fertilizers, pesticides, growth regulators and livestock feed additives to overcome food insecurity, food quality and food safety (Roy *et al*., 2006; Sisay Assefa and Sisay Tadesse, 2019). Organic fertilizers are more environmentally friendly, as it is better for the soil, provide organic matter essential for microorganisms, are one of the building blocks for fertile soil rich in humus, they release nutrients slowly and consistently at a natural rate that plants can use and provide steady results. No danger of over-concentration of any element since microbes break down the material (Sarkar *et al*., 2003). Trace minerals are typically present in a broad range, providing more balanced nutrition to the plant and are safe for all plants with no danger of burning due to salt concentration (Hazra, 2016). It is long-lasting and doesn't leach out since the organic matter binds to the soil particles where the roots have access to it. Once a healthy soil condition is reached, applying a small amount makes it is easier to maintain that level with less work (Hazra, 2016). Organic fertilizer does not over-stimulate exceptional growth, which can cause problems and require more work. On the other hand, Strong plants and grasses are greater resistant to disease and insect attacks (Chen, 2006), and won't build up harmful residues or cause pollution to the environment. Microbes convert the organic matter to the form of nutrients that plants need, which increases soil life, earthworms feeding on organic materials, aerate and loosen the soil (Young *et al*., 2003).

Organic fertilizers are prepared in solid and liquid forms. Compost, vermi compost, different forms of manures are the solid form; and EGOLF, compost extract, Vermi compost extracts, food stillages are the liquid forms of organic fertilizers applied, via root systems as well as via foliar or both (Canfora *et al*., 2015; Kim *et al*., 2015; Jayasundara *et al*., 2016).

One of the sources of liquid organic fertilizers is the organic wastes of traditional markets, whose amount is abundant and is available in all regions, both suburban as well as urban areas. These facts suggest, no doubt, that the continual availability of traditional markets' organic wastes always exists; therefore, every time the community needs them, they are available at all times (Rizqiani, 2007; Hendarto and Suwarno, 2018).

The conversion of traditional market wastes into liquid organic fertilizer means that there is a hope of change from pollution potential into expectation potential of the organic market wastes, in order to support the sustainability of human existence and life (Hendarto *et al.*, 2019). The advantages of this fertilizer were improving soil arrangement, texture and aeration, increasing the soil's water preservation abilities and stimulating healthy root development (Assefa and Tadesse, 2019).

Eco green contains animal and plant extracts and is especially useful as a foliar spray, and the plant can absorb nutrients via comprising leaves, stems, inflorescences and fruits (Pandey *et al*., 2013). This delivery method provides a wide array of plant nutrients, chelating agents, and plant hormones. It has been scientifically proven to be effective in numerous commercial agriculture environments and has its positive traits due to its low chemical-added materials (Hendarto *et al.*, 2019). Liquid fertilizers contain macro and micro nutrients including N, P, K, Ca, S, Fe, Mn, Na, B, Cl, Ni, Cu, Zn, Mo, C and others (Kariada, 2014). Bio substances grow like gibberellin, cytokinin, auxin (BBSDLP, 2008) and the performance of plants can be observed from their aspects of growth, fresh matter production, and the contents of their nutrients (Bhilave *et al.*, 2013). The Sri Lankan Government has launched a national program named "one million of prosperous home gardens" in April 2020 during the global COVID-19 Virus pandemic conditions because of prevalence of kidney disease in the major parts of the country discourage farmers to use synthetic agrochemicals in agriculture (weeraratna, 2013) which strength the home garden concept of utilization of organic fertilizer on vegetables, fruits and cereals due to higher nutrient contents (Suthar and Singh, 2008; Ranasinghe *et al*., 2019a).

While organic fertilizers are generally preferred over chemical fertilizers for environmental concerns, liquid fertilizers supplement additional advantages; according to Kebede (2007), they help in controlling growth; it has less effect on soil health and are easily absorbed by plants. Heavy metals such as cadmium (Cd), arsenic (As), chromium (Cr), lead (Pb), mercury (Hg), nickel (Ni), and vanadium (V), and dioxins may accumulate in soil with repeated fertilizer applications that cause severe health issues, which are well documented by federal and international health and environmental agencies, including the US EPA, the US Public Health Service, and the World Health Organization (Mortvedt, 1995; Binggam *et al.*, 2020). It will also have the potential to save the country's foreign currency that is spent on importing fertilizers. The nation imported seven types of fertilizers with 12.8 million quintals of fertilizers made in the 2022 fiscal year and spent one billion US dollars on importing fertilizers during 2022 (https://newbusinessethiopia.com>agribusiness). Since public awareness of organic liquid fertilizers is still undeveloped, we are facing challenges in selling the product (Kaleab, 2018).

According to the latest research study, the demand of global Liquid Fertilizers Market size & share were valued at approximately USD 2,419.40 million in 2021. The market is expected to grow above a CAGR of 4.20% and is anticipated to reach over USD 3096.805 million by 2028." The report analyses the Liquid Fertilizers market's drivers and restraints, as well as the impact they have on demand throughout the projection period. In addition, the report examines global opportunities in the global Liquid Fertilizers market.

Moreover, studies on the importance, amount, time of application, and method of application of liquid organic fertilizers are not widely adopted in our country. Even if EGOLF Producing PLC, as a company founded in 2007, as a research centre, it began production of organic liquid fertiliser on October 20, 2018, in Arsi, Oromia Regional State, in a ceremony organised by EGOLF (www.ehpea.org, www.globalagriculture.org, www.agriculture.com).

Eco green organic liquid fertilizer main plant is located in the Amhara Regional State, in the North Shoa Zone, about 60 km from Addis Ababa, which is found at a nearby to North Shoa Oromia. But it is not well known and EGOLF is not commonly used in the 13 districts and agricultural experts of the zone, i.e., front line extension agents are not capable to advise small holder farmers including those of Debere Libanos district's as a new innovation. (https://addisfortune.net articles production of liquid fertilizer). So, studies on the effect of different rates of eco-green liquid fertilizer on growth, yield components and yields of onion varieties will determine the economical and optimal rate, best best-performing improved variety.

According to Elisabeth *et al. (*2013), the provision of continuous inorganic fertilizers can lead to decreased land productivity. One way to overcome the further impact that would arise from the use of inorganic fertilizers is through the provision of organic matter. Excessive use of inorganic fertilizer claims an environmental and health issues that deteriorate soil, soil organic matter, soil fertility, increase soil acidity, reduction of biodiversity, whereas organic fertilizations are more environmentally friendly, it is better for the soil, provides organic matter essential for microorganisms, it is one of the building blocks for fertile soil rich in humus, it release nutrients slow and consistently at a natural rate that plants can use and steady result. No dangers of over-concentration of any element since microbes break down the material. Trace minerals are typically present in a broad range, providing more balanced nutrition to the plant and are safe for all plants with no danger of burning due to salt concentration. It is long-lasting and doesn't leach out since the organic matter binds to the soil particles where the roots have access to it. Once a healthy soil condition is reached, applying a small amount makes it easier to maintain that level with less work. Organic fertilizer does not over-stimulate exceptional growth, which can cause problems and require more work. On the other hand, strong plants and grasses have greater resistance to disease and insect attacks (Chen, 2006); they won't build up harmful residues or cause pollution to the environment. Microbes convert the organic matter into the form of nutrients that plants need, which increases soil life. Earthworms feeding on organic materials aerate and loosen the soil (Young *et al*., 2003).

Organic fertilizer is one of the factors that can affect the growth and yield of onions. Onion is weaker than most other crop plants in extracting nutrients from the soil, because of their shallow and unbranched root system and needs to degrade soil bulk density, which causes the lighter soil, thus providing good conditions for the development of the roots and influencing the growth and yield. Agus *et al*. (2006), stated that the weight of the volume of soil is one of the physical properties of soil that is most often defined as a close relation with the ease of root penetration in the soil, drainage and soil aeration. Soil with a high organic matter content has a relatively low volume weight (Lihiang, 2009) and can improve soil fertility; the macro and micro elements increase the nutrient status of the soil. Soil fertility is associated with nutrient mineralization in organic matter and release to soil solution in available form for plant absorption. Mineralization is the result of normal biological cycles within the soil (Paulin and Peter, 2008), which improves biological function (soil health), fertility and physical attributes that include better drainage, reduced compaction and erosion, and improved moisture-holding capability. The conversation is faster due to higher soil moisture and temperature than inorganic N that can be used by plants (Wang *et al.,* 2018). They are very beneficial for the growth of onion having shallow root system and plant uptake of nutrients, vegetative growth and nitrogen fixation, and also stimulates the production of growth-promoting substances like vitamin-B complex, indole acetic acid (IAA) and gibberellic acids, *etc* (Devendra *et al*., 2018) cells bulb formation is more perfect and can accelerate the process of enlargement of onion bulbs and resulting higher weight (Yahumri *et al*., 2015), which leads to increase in onion yield (Akoun, 2004; Kidanu, 2017), improved the chemical and physical properties of onion (Gadelrabh and Elamin, 2013) improving bulb quality and its storability (Geries *et al*., 2012; Kandil *et al.,* 2013; Al-Fraihat, 2016).

Inorganic fertilizers are those fertilizers that are constituted by inorganic chemical substances, i.e., granular triple superphosphate, potassium chloride, urea, anhydrous ammonia, etc. These fertilizers are usually non-biodegradable and are also called artificial or synthetic fertilizers. As they are manufactured in the factories using the latest technologies (Liu *et al.,* 2007). Artificial and inorganic fertilizers have certain disadvantages, as they have to be applied again and again. They become a necessity to the soil, or else the productivity is hampered. They act as a drug for the soils, as till the time the soils are fertilized, they remain productive or else they die down. Eutrophication, nutrient pollution is caused due to the excessive application of artificial fertilizers (Bokhtiar *et al.,* 2005; Kaur *et al.,* 2005).

Excessive use of inorganic fertilizer claims an environmental and health issues that deteriorate soil, soil organic matter, soil fertility, increase soil acidity, reduction of biodiversity, contamination of ground water (Ranaweera *et al.,* 2010; Herath *et al.,* 2014) and problem of health such as chronic kidney disease, methemoglobinemia etc (Sutharsiny *et al.,* 2014; Jayasumana *et al.,* 2015).

Onion plant height, number of leaves, length of roots, bulb fresh and dry weight, bulb diameter, and yield were significantly affected by organic amendments (Bosco, 2017). It has a positive effect on the growth and yield of onions. However, it needs to encourage the farming community to adopt the usage of organic amendments in onion production as opposed to inorganic fertilizers, which are not only expensive but also have a long-term effect on the environment (Bosco *et al*., 2017).

2.5.3. Why and when to use organic liquid fertilizer?

Seeing as liquid manures, organic fertilizers act faster than solid organic ones, they are the best option for seedlings that have exhausted the nutrients provided by newly sprouted seed. It is especially crucial if the fertilizer you are using is a soil-free seed starting mix. While it helps in damping off, it fails to provide adequate nutrients. When seedlings show signs of not having had enough nutrients. If the colour fails to darken after a fertilizer has been added, it is an indication that they have not had a fair share of nutrients.

If you have container-grown plants, liquid fertilizers are what your plants yearn for. Container-grown plants depend entirely on the grower for nutrients and moisture. They need to be fed frequently with an organic liquid fertilizer to thrive. When you are growing cold-tolerant crops, which begin their journey of growth in low soil temperatures. Liquid fertilizers are great for boosting nutrients for such plants since it is difficult to absorb nutrients such as nitrogen in wintry temperatures.

Organic liquid fertilizers are short-acting. Consequently, they are easier to regulate than dry organic ones, which are longer-acting. The ease with which liquid fertilizers can be used makes them quite popular and therefore sustainable (Zafar, 2022). On the other hand, do not mix too much nitrogen-rich fertilizer into the soil. This is not reversible. The release of nitrogen into the soil increases as the temperature rises. You may consequently end up with huge plants but no production. The best time to apply a short-acting fertilizer is just when it is needed by the crop. Then you have fewer chances of overdoing the application. When your plants are well into the season, you can feed them an organic liquid fertilizer to rejuvenate crops such as tomatoes, which live long in the ground. Tomatoes are known to awaken with gusto once you give them two feeds of a good organic liquid fertilizer (https://www.bioenergyconsult.com liquid organic fertilizer). The principles of Health, Ecology, and care are the roots from which organic agriculture grows and develops. They express the contribution that organic agriculture can make to the world and a vision to improve all agriculture in a global context (Luttikholt, 2006).

3. MATERIALS AND METHODS

3.1. Description of the Study Area

Debere Libanos district is one of the 16 districts of the North Shoa zone of the Oromia administrative region (Figure 1). The capital town of the district, Shararo, is found 89 kilometres north of Addis Ababa, on the main road that passes through the capital city of the Amhara region, Bahir Dar.

Geographically, the district is located in 38^o 58’ 33” E longitude and 9^o 63’ 75’’N latitude with altitude ranging from 1500 to 2700 meter above sea level with a maximum and minimum annual temperature of 23^{0}C and 15^{0}C, respectively, (Bosenu *et al.,* 2014) and annual rainfall of 800-1200 mm. The district has 20162 population per 7 km radius.

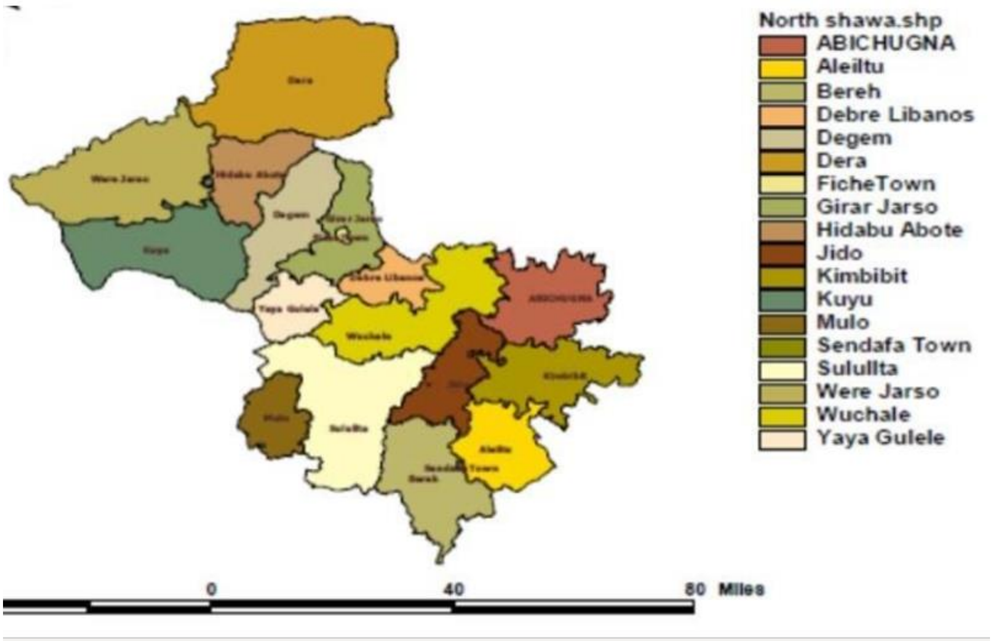

Figure 1. Map of North Shoa Zone weredas, and the place where the experiment was conducted.

The study is further characterized by its bimodal rainfall pattern called main season or summer season that starts from June and stays up to end of September “*meher*” season in local language; and a short rainy season of winter rainfall starts from end of February, which stays up to end of May (Anonymous, 2011). The rainfall of this winter season is known by the "*Belg*" season in local language, which is erratic and has non-uniform distribution. The main rainy season "*meher*" is known by high and continuous rainfall that needs drainage (https://en.wikipedia.org/wiki/deberelibanos).

The soils of the study area are characterized by their vertisols nature (ZARDO, 2010). These soils are highly potential soils that can support different agricultural activities, but are liable to waterlogging and seriously reduce their productivity, which affects the livelihood of farmers. The main occupation of the people in the district is agriculture, characterized by mixed farming (crop production and livestock husbandry). It is a crop dominant and also known by its milk belt area. The main crops grown in the area under rainfed conditions are teff, wheat, faba bean, barley, chickpea, lentils, vetch, Nug, linseed and wild oat. Different vegetables are produced through irrigation, including onion, shallot, carrot, cabbage, beet root and potato.

The study area has a potential for irrigation like *Teltele* (*Wakene*), *Gorowertu* (*Laga jaba*), *Laga wesarbi (Xumano), Dirre jibo* and the like, but farmers are using a traditional flood irrigation system. Since onions is one of the high-value crops, irrigation plays a big role in their production. In Asia, yields from most crops have increased 100-400% after irrigation (FAO, 1996). It allows farmers to apply water at the most beneficial times for the crop, instead of being subject to the timing of rainfall.

3.2. Description of Experimental Materials

The onion varieties named Nasik red, Nafis and Robaf varieties, which were developed and released by Melkasa Agricultural Research Centre (MARC), were used for this experiment (Table 1). Nasik Red and Nafis are more recent varieties that have a higher yield than Bombay Red and Adama Red (Fitsum *et al*., 2021); even Robaf is more recent than Nasik and Nafis. These new onion varieties, Nasik, Nafis and Robaf, which were selected for this experiment, were obtained from MARC.

Table 1. Description of improved Varieties selected for the experiment.

Varieties	Number of days to maturity	Yield at research station (Kg ha^{-1})	Year of release	Pollination Types
Nafis	90-100	40,000	2010	OPV
Nasik red	90-115	30,000	2004	OPV
Robaf	-	-	-	OPV

Source: Performance and adaptability evaluation of improved onion varieties
Where, OPV (Open-pollinated variety); Source: MoANR, 2018.

3.3. Treatments and Experimental Design

The treatments consisted of three varieties of onion (Robaf, Nafis and Nasik red) and four levels of eco-green organic liquid fertilizer (0, 200, 400 and 600) L ha^{-1} and one level of recommended inorganic fertilizer (200kg ha^{-1} NPSB + 150 kg ha^{-1} Urea) was applied as a check for comparison on the experimental plots. The experiment was laid out in a randomized complete block design (RCBD) in a factorial arrangement with three replications. Thus, there were fifteen (3 x 5 = 15) treatment combinations and forty-five (45) experimental units.

3.3.1. Agronomic practice

At the production sites, two agronomic techniques were used: one at the nursery and the other at the production or experimental sites. The seedbed area was ploughed 4 times repeatedly and 40 grams of seeds were sown on a well-prepared seedbed for each variety, having an area of 6 m^2 (6 m x 1 m) with a distance of 10 cm between rows and 3 cm depth on the nursery bed and sown on January 1/2022. The seeds were lightly covered with soil and mulched with grass until the seedlings were emerging. After seeds were germinated, shade was constructed for the germinated seedlings on the seedbed and stayed up until the hardening period. Different agronomic operations were done to keep the plots moisture, free from weed and for better aeration of soil manually on the seedbed and no chemical treatments were carried out during this time. Seedlings were hardened on the seedbed by increasing watering interval for the last two weeks before transplanting. One day before transplanting of seedlings, the nursery was irrigated for safe uplifting of seedlings. Healthy, uniform and vigorous growing seedlings were selected 45 days after sowing on February 15/2022 and transplanted to the experimental plot after attaining 13-15 cm height or when they reached at 3 to 4-leaf stage by carefully uprooting from the nursery bed. This was done late in the afternoon to reduce the risk of transplanting shock and poor establishment. Planting was done on ridges of furrows having 40 cm with 20 cm distance between two rows on the ridge and 10 cm between plants in a double row fashion (Lemma and Shimeles, 2003).

Inventory was done within a week and obtained a result of establishment, *i.e.*, (Robaf=96.33%, Nafis=96.89%, Nasik=96.44% and a total average =96.56%) before replacement. Gap filling was done on the 8th day of transplanting on February 22/2022, to maintain the appropriate plant population. Four-day irrigation interval was maintained for the 1st four weeks and then extended to a seven-day interval up to May 22/2022, until 15 days to harvest, when irrigation was stopped completely using furrow irrigation. All other agronomic practices were applied as per the recommendation made for the crop for all plots throughout the experimental period (Yemane *et al.*, 2013; Guesh, 2015)

Similarly, the selected experimental field was ploughed by oxen 4 times and well prepared before transplanting the seedlings. The field was laid out with the dimensions of 1.8 m x 1 m = 1.8 m^{-2}, having experimental units with a total area of 27 m^2. The overall area of the field was 9.4 m x 24 m=225.6 $m^{2,}$ including between units and block space. The block was separated by one one-meter-wide width open space and the experimental units within a block were separated by 0.5m from each other. The experimental units were well levelled and prepared for transplanting. Transplanting of the seedlings was done after watering. A total of 6 rows and 10 plants per row and 60 plants per experimental unit were found in each experimental unit. Seedlings which was failed to establish were replaced by replanting within a week to maintain the appropriate plant population and four harvestable rows was used for yield data. Each treatment was assigned randomly to the experimental units within a block. The outer one row from each side of all plots was considered as a border and its data is not recorded.

Each litre of EGOLF is diluted or mixed with 20 litre of water and foliar applied at 3 rounds; where, the 1st round application was done after 15 days of transplanting, the 2nd round application was done after 3 weeks of the first application and the 3rd round application was also done before bolting (Feyissa, 2018). Application was done with hand sprayer to minimize spraying out of the experimental units early in the morning when the leaves of the plants were more active and covered all leaves and part of the stem (Organic liquid Fertilizer Producing

Plc., Addis Ababa, www.ehpea.org, www.globalagriculture.org, www.agriculture.com). The total amount of NPSB was applied after the establishment of onion seedlings, fifteen days of transplanting and half of the urea was applied after 45 days of transplanting as side dressing and the remaining half of the urea was applied sixty days after transplanting. Apart from the experimental treatments, all other agronomic activities were applied uniformly as per the recommendation for onion production (EARO, 2004; Husen *et al.,* 2021). Harvesting of onion bulbs was done when 80% plants in each plot showed neck fall. Harvested onion bulbs were cured for 4 days by windrowing on the ground before topping (Habtamu *et al*., 2016).

3.4. Soil Sample and Analysis

Soil sampling was done once from the field by taking random samples in a “zigzag” pattern before transplanting of seedlings. It was taken from the entire experimental field using an auger from 10 representative places to a depth of 0-30 cm, in which the sampling points were at predetermined distances based on the dimensions of the field (Cline, 1944; Franzen and Cihacek, 1998). All samples collected were composited into one kg and dried in the open air, broken down or ground into smaller and finer textures, and sieved through a 2 mm sieve to remove large particles, debris, stones, and other foreign materials. The sieved soil was packed into a clean polythene bag, labelled, and specific soil analysis parameters were carried out at Debereziet, Horticoop Ethiopia soil laboratory enterprise. Soil texture class was determined by Bouyocous hydrometer method (Gobena and R.miller, 2014), soil PH using ES ISO 10390:2014 (1:2.5) and organic carbon was determined by using Walkely and Black method (walkely, 1934), (Alamayo *et al.,* 2022), soil EC using ES ISO 11265:2014 (1:5) Hamere and Teshome, 2018), soil cation exchange capacity (CEC) was determined by ammonium acetate method (FAO, 2008, Alamayo *et al*., 2022), Available phosphorous was determined by using ES ISO 11263:2015 Olsen procedure (Olsen *et al.,* 1954), potassium, sodium, calcium, magnesium, sulphur and molybdenum were determined by using Mehlich-3 (Mehlich, 1984) method, Copper, Iron, Manganese, zinc and boron ware determined by using DTPA extract (Ansa *et al.,* 2022) and total nitrogen was determined by using ES ISO 11261:2015 Kjeldhal method (Bremner and Mulvaney 1982; Alamayo *et al.,* 2022).

3.5. Eco-Green Organic Liquid Fertilizer Analysis

Half litre sample of EGOLF was taken to Debre-Ziet, Horticoop Ethiopia soil laboratory enterprise and analysis was made for pH using ES ISO 10390:2014(1:2.5), (Walkely and Black method (walkely, 1934)), (Alamayo *et al.*, 2022), EC was determined by using ES ISO 11265:2014 (1:5), (Hamere and Teshome, 2018), total N was determined by using ES ISO 11261:2015 Kjeldhal method (Bremner and Mulvaney, 1982) available phosphorous was determined by using ES ISO 11263:2015 Olsen procedure (Olsen, 1954), potassium, sodium, calcium, magnesium, sulphur, copper, iron, manganese, zinc and boron was determined by using Acid Dejection +ICP OES determination (Saydut, 2010).

3.6. Data Collection

3.6.1. Phenology parameters

Days to 80 % maturity (days): Maturity date was taken from the time of transplanting up to 80% maturity of the plant in each plot, *i.e*., when 80% of the plant colour turned from green to yellow, dry and collapse at the neck and computed the mean values (Guesh, 2015).

3.6.2. Growth parameters

Leaf number per plant: All leaves of 12 randomly selected plants were counted from the middle four rows of the net plot size at physiological maturity, and the average was computed for each plot.

Plant height (cm): Plant height of a randomly selected 12 plants from the central four rows of each plot at a physiological maturity of the crop was measured from the ground level up to the tip of the longest leaf using a measuring tape and the average value was computed.

Leaf length (cm): The leaves length of 12 randomly selected plants was measured using measuring tape at physiological maturity and their average was computed.

Leaf width (cm): The leaf width of 12 randomly selected plants was measured using measuring tape at the widest leaf part and their average was computed.

3.6.3. Biomass yield

Fresh weight above ground biomass (g hill^{-1}): The Above ground biomass of 12 randomly selected plants at harvest was measured with a sensitive balance and their average was computed and analysed.

Dry weight of above-ground biomass (g hill^{-1}): The Dry weight of the above-ground biomass of 12 randomly selected plants at harvest was measured with a sensitive balance after drying in an autoclave for 24 hours at 650 °C, and their average was computed.

3.6.4. Yield component and yield

Bulb length (cm): The vertical length, from the bottom to the top of matured bulbs of 12 randomly selected plants in each plot, was measured using a calliper and the mean values were computed (Guesh, 2015).

Bulb diameter (cm): The Bulb diameter of 12 randomly selected plants was measured at right angles to the longitudinal axis at the widest circumference of the bulb from each plot using a calliper and the mean values were computed (Lemma and Shimeles, 2003).

Average bulb weight (g): The average bulb weight of 12 randomly selected onion plant bulbs from the net plot was taken and weighed with a sensitive balance and calculated as the mean fresh bulb weight after harvesting (Guesh, 2015).

Marketable bulb yield (t ha^{-1}): Marketable yield was measured as kg/plot and converted to t ha^{-1}. Clean, undamaged, uniform in colour, insect and disease-free, bulb weighed with a weight greater than 21-160g were considered as marketable yield (Lemma and Shimeles, 2003). The weight of such bulbs obtained from the net plot area was measured in kilograms using a scaled balance and converted to tons ha^{-1}.

Unmarketable bulb yield (t ha^{-1}): -Bulbs having less than 21g, more than 160g weight, misshaped, discoloured, insect and disease affected, decayed and physiologically disordered per plot was considered as unmarketable and was measured as kg plot^{-1} and converted to t ha^{-1} (Lemma and Shimeles, 2003).

Total bulb yield (t ha^{-1}): - The marketable and unmarketable bulb yield was weighed and added and expressed in kg per plot and converted to t ha^{-1} (Guesh, 2015).

3.6.5. Data analysis

Data were subjected to analysis of variance (ANOVA) using R- 4.2.2 version computer software after all measurements were checked for normality. All significant pairs of treatment means were compared using Fisher's protected LSD test at 0.1%, 1%, and 5% probability levels.

3.6.6. Economic analysis

The farming community is primarily concerned with securing food self-sufficiency for their families by producing what they consume or by marketing a certain production of their output to earn cash for getting food. The other farming enterprises also give other necessities for farm families in different directions through cash earnings (Urgessa, 2014). Whether they market little or more, they are interested in the economic return. The main issue is the costs of change from one practice to another, which shows the economic benefits obtained from that change, and makes recommendations (Hayes, 2023). To make a good recommendation, researchers must be able to evaluate alternative solutions of technologies from the user's point of view. It is computed by taking the variable costs of different practices and calculating a partial budget analysis.

Economic analysis was performed to investigate the economic feasibility of treatments. It is a method of organizing experimental data and information about the costs and benefits of various alternative treatments. economic evaluation comprising partial budget with dominance, and marginal rate of return analysis were carried out after average yields adjusted by 10% on undominated treatments in a stepwise manner to reflect the differences in bulb yields between the experimental plot and the farmers' fields for the same treatment and minimum marginal rate of return was considered to be worthwhile opportunity to farmers, the minimum acceptable rate of return should be greater than or equal to 100% (CIMMYT,1988). Partial budget analysis was carried out to identify the rewarding treatment(s) for economically feasible production of onion in Debere-Libanos district gorowertu peasant association.

3.6.7. Correlation analysis

A correlation exists between two variables when the values of one variable are somehow associated with the values of the other variable. It quantifies the extent to which two quantitative variables, X and Y, “go together.” When high values of X are associated with high values of Y, a positive correlation exists. When high values of X are associated with low values of Y, a negative correlation exists (Gogtay and Thatte, 2017). In this experiment, correlation analysis was conducted to evaluate the relationships between growth and yield parameters of onion Varieties as influenced by EGOLF.

4. RESULTS AND DISCUSSION

4.1. Soil Analysis Result

The result of the physical and chemical analysis of experimental soil before planting is depicted in Table 2. The textural class was found to be clay with a particle size distribution of 60% clay, 24% silt and 16% sand (Hazelton and Murphy, 2016). The pH value was 6.96, which is near neutral or sufficient according to the rating of Bruce and Rayment (1982). The optimum pH for onion production ranges between 6 and 8 (Nikus and Fikre, 2010), which is suitable for onion production. The total nitrogen content was 0.27%, which was found in a high range (Tekalign *et al.,* 1991; Havlin *et al*., 2005). Available phosphorus content of the soil was 12.2 ppm (Table 2), which is medium according to Olsen (1954), Hazelton and Murphy (2016). Olsen (1954) stated that the availability of phosphorus>25, 18–25, 10–17, 5–9, and less than 5 mg kg^{-1} is classified as very high, high, medium, low and very low, respectively. The soil organic carbon (2.47%) was found in a moderate range (Charman and Roper, 2007). This shows that the soil was moderate in supplying organic carbon for soil microorganisms and as a source of soil nitrogen mineralization for uptake of mineralized nitrogen to the crop (Hazelton and Murphy, 2007). Similarly, the available sulphur content of 33.35 mg kg^{-1} (Table 2) was high (Horneck *et al*., 2011). While the available boron content (0.65 mg kg^{-1}) was low (Havlin *et al*., 2005). Potassium, calcium, magnesium, iron, manganese, zinc, and molybdenum contents were high and sodium and copper were found to be moderate (Mehlich, 1982), which was adequate for onion production. The cation exchange capacity of the soil was 48.06 meq/100 g, which was very high according to Metson (1961), Landon (1991), and Hazelton and Murphy (2016). Landon (1991) stated that CEC<6, 6–12, 12–25, 25–40, and greater than 40 cmol (+) kg^{-1} are grouped as very low, low, moderate, high and very high, respectively. The very high value of CEC is mainly due to the high clay content of the experimental site. Similarly, (Metson 1961; Landon 1991) reported that the CEC capacity of soil is an important parameter of soil, because it indicates the type of clay minerals present in the soil, and its capacity to retain nutrients against leaching. Clay soils generally have higher CEC values due to their clay content and generally hold more organic matter, whereas sandy soils generally have lower CEC values, where greater leaching of nutrients is expected. The soil also had an EC value of 0.20, which is rated as low according to Mamo and Bekele (2014). The carbon to nitrogen ratio of the study area was 9.08, according to

Hazelton and Murphy (2007), a figure between 10 and 12 is normal for arable soil, and a C: N ratio < 10 indicates a rapid breakdown of organic materials. According to Maria and Yost (2006), organic carbon content of <1.5, 1.5–2.5, and >2.5% is grouped as low, medium and high, respectively. In general, soils of the study area are good in their selected physico-chemical properties for onion cultivation except EC, available phosphorus and boron. On the other hand, a low EC value indicates a non-saline condition of the soil.

Table 2. Soil sample analysis results of the study area before planting.

Soil property parameters	Unit	Result	Target range	Remark
Soil depth	cm	0-25		
Textural proportion	%			
Clay (%)	%	60		
Silt (%)	%	24		
Sand (%)	%	16		
Soil texture class				Clay
Soil pH	-	6.96	5.50-7.00	near to neutral
EC mS/cm	$mScm^{-1}$	0.2	0.40-0.80	Low
P	mg kg^{-1}	12.2	20-30	Low
K	mg kg^{-1}	269.5	90-190	High
Ca	mg kg^{-1}	5689	1000-2000	High
Mg	mg kg^{-1}	1446.83	120-360	High
Na	mg kg^{-1}	76.75	69-161	Moderate
S	mg kg^{-1}	33.35	20-80	Moderate
Fe	mg kg^{-1}	112.06	2.10-5.00	High
Mn	mg kg^{-1}	44.28	1.00-20.00	High
Zn	mg kg^{-1}	4.32	0.50-1.00	High
B	mg kg^{-1}	0.65	0.80-2.00	Low
Cu	mg kg^{-1}	4.21	2.60-5.00	Moderate
Mo	mg kg^{-1}	4.41	0.05-1.00	High
CEC	Meq/100g	48.06	15-25	High
Organic Carbon	%	2.47	1.00-3.00	Moderate
Organic matter	%	4.26	6-Jan	Good
N	%	0.27	0.12-0.25	High
C: N	-	9.08		

Source: Debereziet Horticoop Ethiopia (Horticulture) plc soil and water analysis laboratory August 2022.

4.2. Chemical Properties of Eco-green Organic Liquid Fertilizer

Eco-green organic liquid fertilizer sample was taken from the product purchased for the experiments, labelled and specific organic liquid fertilizer analysis parameters were carried out at Debereziet, Horticoop Ethiopia soil laboratory enterprise. The analysis result was indicated in Table 3. It has 12 available macro and micro nutrients, which are important for plant nourishment, growth, and development.

Table 3. Chemical properties of eco-green organic liquid fertilizer

Chemical properties	Unit	Result
pH	-	6.06
EC mS/cm	mS/cm	5.53
Available phosphorous	mg/kg	159.18
Potassium	mg/kg	982.86
Calcium	mg/kg	827.92
Magnesium	mg/kg	132.26
Sodium	mg/kg	69.58
Sulphate	mg/kg	119.04
Iron	mg/kg	56.61
Manganese	mg/kg	10.02
Zinc	mg/kg	2.21
Boron	mg/kg	3.03
Copper	mg/kg	0.42
Total Nitrogen	%	0.57

Source: Debereziet Horticoop Ethiopia (Horticulture) plc soil and water analysis laboratory August, 2022.

4.3. Phenology and Growth Parameters of Onion as Influenced by Variety and Eco-green Organic Liquid Fertilizer

4.3.1. Days to maturity

The analysis of variance indicated that days to 80% maturity of onion were significantly ($p<0.05$) influenced by the main effect of variety and EGOLF rate, but were not significantly affected by the interaction of the two factors (Appendix Table 1).

Due to the main effect of EGOLF, the lowest days (110.22 days) to mature was recorded from the control treatment (0 L ha^{-1} EGOLF) while the highest number of days (124.56 days) to mature was recorded from the application of 200 NPSB + 150 urea kg ha^{-1} (recommended fertilizer), which was statistically at par with the application of 600 L ha^{-1} and 400 L ha^{-1} EGOLF (Table 4). Intermediate maturity was recorded from the application of 200 L ha^{-1} EGOLF. This might be associated with the combination effect of N found in EGOLF and the soil and experimental plots treated with NPSB + urea with N found in the soil attributed to nitrogen enhancing plant biochemical processes and promotes luxuriant and succulent vegetative growth dominating the bulb formation phase and extending the vegetative growth period of onion plants leads to late maturity (Brewster, 1994; Marschner, 1995).

Table 4. Main effects of variety and EGOLF rate on phenological and growth parameters of onion at Debere-Libanos district during the 2022 cropping season under irrigation.

Treatments	DM (g)	PH (cm)	LW (cm)
Fertilizer			
200NPSB+150Urea (kg ha^{-1})	124.56^{a}	54.48^{a}	1.68^{ab}
0 (L ha^{-1})	110.22^{c}	46.13^{c}	1.43^{c}
EGOLF 200 (L ha^{-1})	$114,22^{b}$	55.29^{a}	1.76^{a}
EGOLF 400 (L ha^{-1})	121.89^{a}	54.62^{a}	1.61^{b}
EGOLF 600 (L ha^{-1})	124.11^{a}	51.45^{b}	1.57^{bc}
Mean	119	52.4	1.61
LSD (5%)	2.67	2.86	0.15
Variety			
Robaf	119.2^{ab}	52.37^{b}	1.61^{ab}
Nafis	120.33^{a}	54.64^{a}	1.71^{a}
Nasik	117.47^{b}	50.18^{b}	1.52^{b}
Mean	119	52.4	1.61
LSD (5%)	2.07	2.21	0.12
CV (%)	2.33	5.65	9.85

Where, DM=days to maturity; PH= Plant height; LW= Leaf width; EGOLF=Eco green organic liquid fertilizer; means within the same column that share the same letter (s) are not significant at a 5% significance level.

Due to the main effect of variety, early maturity (117 47 days) was recorded in Nasik variety, which was statistically at par with variety Robaf (Table 4). On the other hand, late maturity (120.33 days) was recorded in variety Nafis, but it did not significantly differ from variety

Robaf. This might be associated with their inherent genetic variability among the varieties. It is in agreement with Awoke *et al. (*2021) report that improved onion variety Nafis matured later (110.67 days), followed by Bombay Red (107.83 days), Nasik Red (106.0 days) and Adama Red (105.67 days). Gezahegn and Awoke (2022) also reported that the days to 75% maturity were significantly (at $P<0.001$) influenced by the varieties, which is related to this study.

Table 5. Interaction effect of EGOLF rates and Varieties on plant leaf number of onion at Debere-Libanos district during the 2022 cropping season under irrigation.

Treatments	Varieties			
Fertilizer	Robaf	Nafis	Nasik	Mean
200NPSB+150Urea (kg ha^{-1})	14.85^{a}	15.10^{a}	14.75^{a}	14.9
0 (Lit ha^{-1})	9.66^{c}	12.86^{b}	9.45^{c}	10.66
EGOLF 200 (L ha^{-1})	14.86^{a}	15.11^{a}	14.64^{a}	14.87
EGOLF 400 (L ha^{-1})	14.90^{a}	15.14^{a}	14.80^{a}	14.95
EGOLF 600 (L ha^{-1})	14.96^{a}	15.16^{a}	14.82^{a}	14.98
LSD (5%)		1.37		
CV		5.83		

The result is in agreement with the findings of various researchers who observed extended vegetative growth of various vegetables, including onion, with a high rate of compound and blended fertilizers, as well as of nitrogen fertilizer, while plants that did not receive nitrogen fertilizer matured earlier. When the level of nitrogen increases, the onion plants attributed to prolonged canopy and maintain physiological activity for an extended period, thereby continuing photosynthesis to the extended period to maturity. Similarly, (Brewster, 1994; Guesh, 2015), Marschner (1995), Girma (2011) and Negasi *et al*. (2017) also reported that days to maturity of onion was prolonged in response to increased level of farmyard manure and nitrogen. According to Khan *et al*. (2002), nitrogen rate above 100 kg ha^{-1} delayed maturity. It is also similar with the study conducted by Gebremedhin *et al*. (2018) at the North Western Zoze of Tigray. Even if there were not enough findings done on onion and other vegetable plants with EGOLF, which is high in total nitrogen (5700 mg L^{-1}) for the growth and development of onion plants, the results are in agreement with the findings of the indicated researchers.

Table 6. Interaction effect of EGOLF rates and Varieties on plant leaf length (cm) of onion at Debere-Libanos district during the 2022 cropping season under irrigation.

Treatments	Varieties		
Fertilizer	Robaf	Nafis	Nasik
200NPSB+150 Urea (kg ha^{-1})	38.32^{b}	38.76^{b}	37.82^{b}
0 (L ha^{-1})	23.32^{d}	26.62^{c}	21.64^{e}
EGOLF 200 (L ha^{-1})	41.72^{a}	42.20^{a}	41.18^{a}
EGOLF 400 (L ha^{-1})	38.93^{b}	39.38^{b}	38.42^{b}
EGOLF 600 (L ha^{-1})	38.50^{b}	38.95^{b}	38.00^{b}
LSD (5%)		166	
CV		2.75	

4.3.2. Plant height

The analysis of variance revealed that the main effect of variety and EGOLF had a significant ($p<0.01$, 0.001) influence on the plant height of onion, respectively (Appendix Table 1). However, there was no significant interaction between variety and EGOLF on this parameter. About variety, the highest (54.64 cm) onion plants were recorded in Nafis variety, while the shortest (50.18 cm) plants were recorded in Nasik variety, which was statistically at par with Robaf variety (Table 4).

About EGOLF, the highest (55.29 cm) plants were observed by the application of 200 L ha^{-1}, which was statistically similar to the treatment received 400 L ha^{-1} EGOLF and recommended inorganic fertilizer (200 NPSB +150 Urea kg ha^{-1}) (Table 4). On the other hand, the shortest (46.13 cm) plant height was obtained from plots that received no fertilizer.

In general, the application of EGOLF increased the plant height of onion varieties as compared to growing varieties without EGOLF application. Interestingly, EGOLF had similar effects on the plant height of onion as that of the recommended inorganic fertilizer (200 NPSB +150 Urea kg ha^{-1}). The increased plant height due to the increased rate of EGOLF could be attributed to the increased availability of essential plant nutrients in the soil for uptake by plant roots, which might have sufficiently enhanced vegetative growth through increasing cell division and elongation. The difference between varieties might be due to the genotypic difference for plant height. Plant height might be affected by genetic and environmental factors, as well as by their interaction. Samad *et al.* (2019) showed that the effect of giving multipurpose SS organic liquid fertilizer had a very significant effect on plant height. Vedpathak and Chavan (2016) found that the plant height of onion mostly increases with the application of compost prepared from agricultural solid waste as compared to the application of inorganic fertilizer alone. Feyissa (2018) studied the effect of EGOLF on tomato and found the highest result in combination with Urea, which is different from this study. Daniel *et al*. (2022) conducted on malt barley and showed that the effect of EGOLF was statistically significant on Plant height between the control and Eco-green levels (60, 80, and 100 L ha^{-1}), but no statistically significant variation was obtained from 20, 40 L $ha^{-1.}$ There was no statistically significant variation of Plant Height between the Eco-green levels 60, 80, and 100 L·ha^{-1}. The crop and the level of EGOLF were different and the result obtained was also different from this study, but related. Aklok *et al*. (2018) report showed that the main effect of EGOLF affected onion leaf length, with the highest values obtained from 400, 500, and 500 L·ha^{-1} EGOLF were 36.5 cm, which is the main factor of onion plant height. This might be associated with their inherent genetic variability among the varieties. It is in agreement with Awoke *et al.* (2021), Gebremedhin *et al*. (2018), and Wubetie *et al. (*2022), who indicated the significant differences among onion varieties in plant height between improved onion varieties. But Gezahegn and Awoke (2022) reported differently that varietal had not significantly influenced plant height (P>0.05).

4.3.3. Number of leaves

The analysis of variance showed that the number of leaves per hill was significantly ($p<0.05$) affected by the main effect of variety and EGOLF as well as by the interaction of the two factors (Appendix Table 1).

Due to the interaction effect, the highest number (15.16) of onion leaves per hill was obtained by the application of 600 L ha^{-1} eco-green with Nafis variety, which was statistically similar to the treatments received 400 L ha^{-1} eco-green + Nafis, 200 L ha^{-1} eco-green + Nafis, Recommended inorganic fertilizer + Nafis, 600 L ha^{-1} + Robaf, 400 L ha^{-1} eco-green + Robaf, 200 L ha^{-1} eco-green + Robaf, Recommended inorganic fertilizer + Robaf, 600 L ha^{-1} eco-green + Nasik, 400 L ha^{-1} eco-green + Nasik, 200 L ha^{-1} eco-green + Nasik, and Recommended inorganic fertilizer + Nasik (Table 5). On the other hand, the lowest number

(9.45) of leaves per hill was recorded by the application of 0 L ha^{-1} with Nasik variety, which was statistically similar to the application of 0 L ha^{-1} with Robaf variety. An intermediate number (12.86) of leaves per hill was obtained from the treatment that received 0 L ha^{-1} eco-green with the Nafis variety.

Alemu *et al.* (2020) and Gosa *et al*. (2022) reported that the interaction effect of variety and fertilizer significantly affected the leaf number of onion, which agrees with this study. However, Wubetie *et al. (*2022) showed that there was no appreciable difference in leaf number between the Nasik red (8.73), Robat (8.34), and Nafis (8.32) varieties.

4.3.4. Leaf length

The analysis of variance result indicated that leaf length was significantly ($p<0.001$) influenced by the application of different rates of EGOLF and variety, and ($p< 0.05$) with an interaction effect (Appendix Table 1). In the interaction effect, the longest leaves (42.20cm) were recorded from treatments that received EGOLF with the rate of 200 L ha^{-1} of Nafis variety and the shortest leaves (21.64cm) were observed from the non-fertilized treatment Nasik variety (Table 6). The longest leaf of Nafis (42.20cm) was greater than the shortest leaf of Nasik (21.64cm) by 48.72% in length (Table 6). On the other hand, the length of leaves of onion was statistically similar to Robaf and Nasik varieties recorded from treatments that received 200 L ha^{-1}. On the main effect, the longest leaf of Nafis (37.18cm) was greater than the shortest leaf of Nasik (35.41cm) by 4.76% in length (Table 6). However, the three improved onion varieties were statistically significant on leaf length. This result might be due to the interaction effect of EGOLF rates and Varieties. Even if the level of EGOLF used was different from this study, Aklok *et al*. (2018) suggested that EGOLF affected onion leaf length, with the highest values obtained from 400, 500, and 500 L·ha$^{−1}$ OLF were 36.5 cm. Rongting *et al. (*2017) study on (*Chrysanthemum morifolium* Ramat.) shows that each type of liquid organic fertilizer produced greater seedling growth on leaf length than NPK treatment by 15.9% on leaf length. Other studies conducted by Mondal *et al.* (1986), Ghafoor *et al. (*2003), Jilani *et al.* (2010), and Yemane *et al.* (2014) also reported that leaf length was influenced by differences among cultivars. Diribsa *et al.* (2022) also reported that Leaf length was significantly influenced by the effect of plant spacing and varieties. Wubetie *et al. (*2022) indicated the significant differences among onion varieties in plant leaf lengths between improved onion varieties (Nasik red, Nafis and Robat).

4.3.5. Leaf width (cm)

The analysis of variance showed that leaf width was significantly ($p<0.05$) affected by the main effects of EGOLF and NPSB + Urea fertilizer (Appendix Table 1). However, there was no significant interaction between the two factors for this parameter.

Due to the main effects of EGOLF, the widest leaves (1.76 cm) were recorded from plots that received 200 L ha^{-1} of EGOLF, which was statistically par with the treatments that received the recommended inorganic fertilizer rate (200 NPSB +150 Urea kg ha^{-1}) (Table 4). While the narrowest leaves (1.43 cm) were recorded from non-fertilized control plots, which were not significantly different from the treatment that received 600 L ha^{-1} EGOLF. The increase in leaf width/ size of the onion might be due to the supply of nutrients in EGOLF, which was applied in foliar, and initially available nutrients in the soil, as required amount, favour the growth and development of the plant for cell division of onion plants.

Due to the main effect of variety, the widest leaves (1.71 cm) were recorded in Nafis variety, which was not significantly different from Robaf variety (Table 4). On the other hand, the narrowest leaves (1.52 cm) were observed in the Nasik variety. This difference might be due to the genetic variation or the environment of the three improved onion varieties where it has been grown (G. Acquaah, 2015). Diribsa *et al. (*2022) also reported that, leaf diameter was greatly influenced by intra-row spacing and varieties, whereas the interactions did not show significant results. Wubetie *et al. (*2022) indicated the significant differences among onion varieties in plant width/diameters of onion leaves between improved onion varieties (Nasik red, Nafis and Robat).

4.3.6. Fresh weight of above-ground biomass (g $plant^{-1}$)

The analysis of variance showed that different levels of EGOLF and using different onion varieties were significantly ($p<0.01$) affected the aboveground biomass of onion (Appendix

Table 1). However, the interaction between EGOLF rates and variety did not significantly affect above-ground biomass.

Table 7. Main effects of eco green organic liquid fertilizer and variety on fresh and dry aboveground biomass of onion in Debere Libanos district.

Treatments	FAGB (g hill^{-1})	DWAGB (g hill^{-1})
Fertilizer		
200 NPSB+150 Urea (kg ha^{1})	59.80^{a}	4.19^{a}
0 (Lit ha^{-1})	39.12^{b}	2.84^{b}
EGOLF 200 (L ha^{-1})	62.90^{a}	4.40^{a}
EGOLF 400 (L ha^{-1})	56.20^{a}	3.93^{a}
EGOLF 600 (L ha^{-1})	54.64^{a}	3.83^{a}
Mean	54.53	3,84
LSD (5%)	11.17	0.78
Variety		
Robaf	52.57^{b}	3.72^{b}
Nafis	62.53^{a}	4.36^{a}
Nasik	48.50^{b}	3.43^{b}
Mean	54.53	3.84
LSD (5%)	8.65	0.6
CV (%)	21.21	20.95

Where, FABG=Fresh weight of Aboveground biomass; DWAGB=Dry weigh of aboveground biomass; means within the same column that share the same letter (s) are non-significant at 5% significance level.

Due to the main effects of EGOLF, the highest fresh weight of above ground biomass (62.90 g plant^{-1}) was observed from the plot received EGOLF at the rate of 200 L ha^{-1}. It was statistically similar with those plants supplied with 200 NPSB + 150 Urea kg ha^{-1}, 600 L ha^{-1}, 400 L ha$^{-1,}$ EGOLF, respectively while the lowest weight (39.12 g plant^{-1}) was observed from unfertilized plots (Table 7). Nafis variety was the highest (62.53 g plant^{-1}) and Nasik was the lowest (48.5 g plant^{-1}) in weight, which was statistically similar to Robaf variety.

These might be due to the supplied nutrients in EGOLF, which was applied in foliar and initially available nutrients in the soil, as the required amount favors the growth and development of the plant. Foliar sprays also appear to act as catalysts, increasing nutrient uptake by plants and storage of carbohydrate at the bulb from the aboveground part for bulb quality at physiological maturity. Aklok *et al*. (2018) reported that the main effect of

EGOLF affected bulb fresh weight, with the highest values obtained from 500 L·ha^{-1} OLF being 46.8 g/bulb.

4.3.7. Dry weight of above-ground biomass (g plant^{-1})

The application of different levels of EGOLF and variety significantly ($p<0.05$) affected the dry weight of the above-ground biomass of onion (Appendix Table 1). However, the interaction between EGOLF rates and variety did not significantly affect the dry weight of above-ground biomass. The highest dry weight of above-ground biomass of onion plants (4.40 g plant^{-1}) was observed from EGOLF supplied at the rate of 200 L ha^{-1}. It is statistically similar to those plants supplied with 200 NPSB + 150 Urea kg ha^{-1}, 400 L ha^{-1}, 600 L ha^{-1}, EGOLF, respectively. The lowest above-ground biomass (2.84 g plant^{-1}) was observed from the fertilized treatments (Table 7). These might be the moisture content reflection of the above-ground biomass after drying. Nafis variety was the highest (4.36 g plant^{-1}) and Nasik was the lowest (3.43 g plant^{-1}) in DWAGB, which was statistically similar to Robaf variety. (Abrahaley *et al.* (2020) reported that Application of nitrogen and farm yard manure affects DWAGBM of onion significantly ($p< 0.05$) by the main effect of N, Farm yard manure and their interaction effect, the main effect is similar with this finding except its level difference but the interaction effect is completely different with this findings. On the other hand this findings were completely different from the findings of Tegebew (2022), which shows Cultivar had no significant main effect on onion shoot fresh and dry weight.

4.4. Yield Parameters of Onion as Influenced by Variety and GEOLF

4.4.1. Bulb length (cm)

The analysis of variance shows that, bulb length of onion was highly significantly ($p<0.01$) influenced by the main effect of EGOLF and variety (Appendix Table 2). However, there was no significant interaction effect between the two factors for this parameter.

Due to the main effect of EGOLF, the highest bulb length (6.81cm) was recorded from plots supplied with 200 L ha^{-1} EGOLF. Whereas the lowest (5.17cm) was observed from unfertilized control plots, which was statistically at par with the rate 600 L ha^{-1} EGOLF (Table 8).

Due to the main effect of variety, the highest bulb length (6.44 cm) was recorded in the Nasik variety, which was not significantly different from the Robaf variety (Table 8). On the other hand, the lowest (5.53cm) in bulb length was observed in the Nasik variety, which was not significantly different from the Robaf variety. Dadi *et al. (*2022) study conducted on four varieties, Nafis, Nasik red, Robaf, and Bombay red, revealed that onion varieties significantly affected bulb diameter and bulb length. The maximum bulb diameter (5.26 cm) and bulb length (4.83 cm) were recorded from Nafis varieties, which are statistically similar to those of the Bombay red variety, while the lowest bulb diameter (4.12 cm) and bulb length (4.09 cm) were observed from the Nasik red variety. This is due to the reality that varieties can have different genetic makeup, or the environment in which the three improved onion varieties where it has been grown (G. Acquaah, 2015) makes them different. A similar finding was reported by Rhael and Tolessa (2018) that the genotypic difference in the varieties of onions affects bulb length and diameter, which is similar to this finding. Wubetie *et al. (*2022) also indicated the significant differences among varieties ($p< 0.05$) in onion bulb length and diameter.

4.4.2. Bulb Diameter (cm)

The analysis of variance revealed that, bulb diameter of onion was very highly significantly ($p<0.001$) influenced by the main effects of EGOLF and variety (Appendix Table 2). However, there was no significant interaction effect between the two factors for these parameters.

Due to the main effect of fertilizer, the highest bulb diameter of 7.63cm of onion plants was obtained from 200 NPSB + 150 Urea kg $ha^{-1,}$ which was statistically at par with EGOLF supplied at the rate of 200 L ha^{-1}. The lowest bulb diameter of 5.63 cm was observed from unfertilized plots (Table 8).

Due to the main effect of variety, the highest bulb diameter (7.42 cm) was recorded in the Nafis variety (Table 8). Nasik was the lowest (6.16cm) in bulb diameter, which was statistically similar to the Robaf variety. This result is in agreement with the study conducted by Kumar *et al*. (1998), Nasreen *et al*. (2007), Abdissa *et al*. (2011), and Muluneh *et al.* (2019). On the other hand, Gezahegn and Awoke (2022) reported that there was no significant influence ($p>0.05$) of varietal effect on bulb diameter, which was different from these findings. Regardless of levels, maximum fertilization of N increased the mean bulb diameter about the control treatments. Larger bulb diameter with higher yield in Onion due to "N" application is likely because Nitrogen encourages cell elongation, above-ground vegetative growth, and imparts dark green colour of leaves. Dadi *et al. (*2022) study conducted on four varieties, Nafis, Nasik red, Robaf, and Bombay red, revealed that onion varieties significantly affected bulb diameter and bulb length. The maximum bulb diameter (5.26 cm) and bulb length (4.83 cm) were recorded from Nafis varieties, which are statistically similar to those of the Bombay red variety, while the lowest bulb diameter (4.12 cm) and bulb length (4.09 cm) were observed from the Nasik red variety. This is due to the reality that varieties can have different genetic makeup that makes them different. A similar finding was reported by Rhael and Tolessa (2018), as the genotypic difference in the varieties of onions affects bulb length and diameter, which is similar to these findings.

4.4.3. Average bulb weight (g)

The analysis result shows that, bulb weight of onion plant was significantly ($p<0.001$), ($p<0.01$) influenced by the application of different rates of EGOLF and variety, respectively (Appendix Table 2). The highest bulb weight, 123.97 g plant^{-1} of Onion bulb, was obtained from EGOLF supplied at the rate of 200lit ha^{-1} (Table 8) which was 49.98% bigger than the bulb weight obtained from non-fertilized treatments (82.66 g^{-}plant^{-1}). The highest bulb weight was statistically similar to those plants supplied with 400 lit ha^{-1} EGOLF, 200kg ha^{-1} NPSB with 150 kg ha^{-1} urea and 600 L ha^{-1} EGOLF, respectively. The lowest plant bulb weight of 82.66g plant^{-1} was obtained from non-fertilized treatments (Table 8). Nafis variety was the highest (119.74 g^{-}plant^{-1}), which was statistically similar to Robaf variety, and Nasik was the lowest (104.89 g^{-}plant^{-1}) in average bulb weight, which was statistically similar to Robaf variety. Aklok *et al*. (2018) study shows that the main effect of EGOLF affected onion bulb fresh weight, with the highest values obtained from 400, 500, and 500 L ha^{-1} EGOLF were 46.8 g bulb$^{-1,}$ which agrees with its significant effect on average bulb weight, except for the EGOLF level used. Another study conducted by Kashi and Frodi (1998), Greenwood *et al.*

(2001), Khan *et al*. (2002), Abdissa *et al*. (2011), and Muluneh *et al*. (2019) showed that there was a statistically significant ($p<0.001$) difference in mean bulb weight due to the application of N at different levels.

Dadi *et al. (*2022) reported that single bulb weight was affected by the varieties. The highest single bulb weight (103.63 g) was obtained from the Nafis variety, which is statistically similar to the Bombay red variety. The lowest single bulb weight (82.63 g) was obtained from Nasik red, which is statistically similar to that of the Robaf variety. The result was in agreement with the findings of Yirga *et al. (*2020) who reported that, Nafis variety was larger than other varieties, which is similar to this study. Wubetie *et al. (*2022) also indicated the significant differences in bulb weight among varieties and a less significant influence by intra-row spacing. On the contrary, Gezahegn and Awoke (2021) reported that Onion bulb weight was not significantly ($p<0.05$) affected by varietal effect.

4.5. Yield of Onion as Influenced by Variety and GEOLF

4.5.1. Marketable bulb yield (t ha^{-1})

The analysis of variance revealed that, the marketable bulb yield of onion was very highly significantly ($p<0.001$) influenced by the main effects of EGOLF and variety (Appendix Table 2). However, the interaction effect of the two factors did not significantly influence this parameter.

Due to the main effects of EGOLF, the highest marketable bulb yield (35.66 t ha^{-1}) was obtained from plots supplied with 200 L ha^{-1} EGOLF, which was statistically at par with the treatments that received recommended inorganic fertilizer (200 NPSB + l50 Urea kg ha^{-1}) (Table 8). On the other hand, the lowest marketable bulb yield (14.63 t ha^{-1}) was obtained from an unfertilized plot. In general, application of EGOLF at the rate of 200 L ha^{-1} increased marketable bulb yield by 143.75% compared with the control plot. In other words, application of EGOLF at the rate of 200 L ha^{-1} resulted in more than 2-fold enhancement in marketable yield over the control plot. This yield advantage was achieved due to the positive effect of EGOLF that had increased plant height, number of leaves, leaf length, leaf width, above-ground biomass, bulb length, bulb diameter, and bulb weight that cumulatively increased the marketable bulb yield. However, the result of the current study indicated that the yield advantages obtained from levels of EGOLF beyond 200 L ha^{-1} application were significantly lower. This showed that supplying EGOLF at the rate of 200 L ha^{-1} was found to be adequate or optimum to produce the maximum marketable bulb yield of onion. Interestingly, this study also indicated that fertilization using EGOLF at the rate of 200 L ha^{-1} can substitute the use of the recommended inorganic fertilizer rate (200 NPSB +150 Urea kg ha^{-1}) when the desirable parameter, marketable bulb yield of onion, is considered.

Table 8. Main effect of eco green organic liquid fertilizer and variety on yield and yield components parameters of onions in Debre Libanos district.

Treatments	BL (cm)	BD (cm)	ABW (g)	MBY (t ha^{-1})	TBY (t ha^{-1})
200 NPSB+150 Urea (kg ha^{1})	6.07^{b}	7.63^{a}	118.66^{a}	34.72^{ab}	35.52^{a}
0 (Lit ha^{-1})	5.17^{c}	5.63^{c}	82.66^{b}	14.63^{d}	15.36^{c}
Eco green 200 (L ha^{-1})	6.81^{a}	7.00^{ab}	123.97^{a}	35.66^{a}	36.53^{a}
Eco green 400 (L ha^{-1})	6.04^{b}	6.68^{b}	119.12^{a}	32.45^{bc}	33.47^{ab}
Eco green 600 (L ha^{-1})	5.68^{bc}	6.31^{bc}	116.99^{a}	30.70^{c}	31.70^{b}
Mean	5.96	6.65	112.28	29.63	30.52
LSD (5%)	0.61	0.73	11.63	3.08	3.15
Variety					
Robaf	5.90^{b}	6.37^{b}	112.20^{ab}	29.34^{b}	30.32^{b}
Nafis	6.44^{a}	7.42^{a}	119.74^{a}	32.35^{a}	33.23^{a}
Nasik	5.53^{b}	6.16^{b}	104.90^{b}	27.21^{b}	28.00^{b}
Mean	5.96	6.65	112.28	29.63	30.52
LSD (5%)	0.47	0.57	9.01	2.39	2.44
CV (%)	10.64	11.4	10.72	10.77	10.68

Where, BL = Bulb length, BD = Bulb diameter, ABW = above ground biomass, Marketable bulb yield, Unmarketable bulb yield, TBY = Total bulb yield.

Due to the main effect of variety, the highest marketable bulb yield (32.35 t ha^{-1}) was obtained in Nafis variety, whereas the lowest (27.21 t ha^{-1}) was recorded in Nasik variety, which was statistically at par with Robaf variety (Table 8). Although only three onion varieties were tasted in the present study, differences in genetic factors existed in plants, resulting in diversity in the marketable bulb yield. In line with this result, Gautam *et al*. (2006) and Gezahegn and Awoke (2022) reported that the marketable bulb yield of onion was significantly affected by varieties. Similarly, Gebremedhn *et al.* (2018) reported that cultivars may perform differently under diverse agro-climatic conditions and various cultivars of the same species grown even in the same environment with the same management often yield differently due to the genetic makeup of the cultivars and the interaction effects of genotype x environment or genotype x management. Furthermore, Yemane *et al.* (2013) and Gautam *et al.* (2006) indicated that the yield of fresh onion bulbs was significantly affected by varieties. In agreement with this finding, Rajcumar (1997), Jilani (2004) and Geremew *et al*. (2010) also reported a significant difference within varieties for marketable bulb yield in onion, but Wubetie *et al.* (2022) reported differently that Marketable bulb yield was not significantly affected by different varieties.

4.5.2. Unmarketable bulb yield (t ha^{-1})

The analysis result obtained shows that the application of different levels of EGOLF, variety, and their interaction was not significant at the 5% probability level on unmarketable bulb yield (Appendix Table 2).

4.5.3. Total bulb yield (t ha^{-1})

The analysis of variance revealed that the total bulb yield of onion was very highly significantly ($p<0.001$) influenced by the main effects of EGOLF and variety (Appendix Table 2). However, the interaction effect of the two factors did not significantly influence this parameter. Due to the main effects of EGOLF, the highest total bulb yield (36.53 t ha^{-1}) was obtained from plots supplied with EGOLF treated with 200 L ha^{-1} which were statistically similar with the treatments which received (200 NPSB + 150 Urea kg ha^{-1}) and at par with 400 L ha^{-1} of EGOLF and the lowest (15.36 t ha^{-1}) from unfertilized plot. However, the interaction between EGOLF rates and variety did not significantly affect total bulb yield. In general, application of EGOLF at the rate of 200 L ha^{-1} increased marketable bulb yield by 137.83 % compared with the control plot. This yield advantage was the reflection of the marketable bulb yield obtained. When the level of EGOLF and temperature rise, the release of nitrogen into the soil increases and onion plants start to split, which may consequently end up with huge plants but no production. Aklok *et al*. (2018) study shows that the main effect of EGOLF affected onion total bulb yield, with the highest values obtained from 400, 500, and 500 L·ha^{-1} OLF were 46.2 L·ha^{-1}.

A preliminary trial unpublished result report made by Relief Society of Tigray (RST) shows that, at the Tigray regional state, kola tembein and wekro EGOLF treated plants were healthy, with fast growth, deep green colour, and a much quicker root expansion and rooted vertically and fibrous, as a result, better yield per plant or hectare was obtained (Tadese, 2011). The yield per plant was better than that of the untreated by 50—100% using 200 L ha^{-1} on onion, tomato, and pepper.

Due to the main effect of variety, the highest total bulb yield (33.23 t ha^{-1}) was obtained from Nafis onion variety and the lowest (28.00 t ha^{-1}) was obtained from Nasik variety, which was statistically at par with Robaf variety (Table 8).

Fistum and Gadissa's (2019) study conducted at Lume, dugda, Adama and Adamitulu-Jidokombolcha districts shows that Nafis was found as the best onion variety and farmers also preference to Nafis variety, which produces a higher yield than Nasik red and Bombay red verities in the four districts and based on the bulb size and preference at market places in addition to productivity. Fistum *et al.* (2021) and Dadi *et al.* (2022) report shows similar results to this study. Wubetie *et al.* (2022) reported that total bulb yield was not significantly affected by different varieties.

4.6. Economic Optimum Rate of EGOLF for Onion Cultivation in the Study Area.

The benefit of each variety was calculated by including the costs of fertilizer (EGOLF, inorganic), and another variable cost like labour, transport, and bagging costs. The average field market price of onion was 50.00 ETB kg^{-1} during the harvested period, the farm got the price of NPSB 40.00 ETB kg^{-1}, Urea 60.00 ETB kg^{-1}, the company price of EGOLF was 70.00 ETB L^{-1} and the Labour cost of 200 ETB man^{-1} day^{-1} was considered and undominated and dominated treatments was selected.

The result of the cost-benefit analysis related to the application of different rates of EGOLF and one level of NPSB + Urea with three varieties (Robaf, Nafis and Nasik) is presented in Tables 12 and 13. Generally the foliar application of EGOLF in combination with onion varieties provide the highest net income of 1028185.42 ETB ha^{-1} with the highest marginal rate of return of 6660.48% (Table) from Nafis variety with the application rate of 200 L^{-1} EGOLF, This implies that for every 1 ETB investment on the EGOLF on Nafis onion variety in the Gorowertu peasant association earn additional 66.61 ETB economic return. The agronomic result agrees with the economic return obtained from the experiment.

1. The net benefits of EGOLF, 200, 400, 600 L ha^{-1} and one level of NPSB + Urea (200 NPSB+150 Urea kg ha^{-1}) supplied with Robaf varieties exceed those of their control. The highest net benefit (938288.1 ETB) was obtained from 200 L ha^{-1} EGOLF from different levels, and the lowest net benefit (391770 ETB) was obtained from unfertilized treatment. The benefit of inorganic fertilizer (200 NPSB+150 Urea kg ha^{-1}) level result showed (887338.1 ETB), (Table 12) and the highest marginal rate of return was obtained from Robaf variety supplied with 200 L ha^{-1} followed by the unfertilized treatment with the value of 12155.62% and 1702.184% respectively (Table 13). This implies that for every 1 ETB investment on the EGOLF on Robaf onion variety in the Gorowertu peasant association, they earn an additional 121.56 ETB economic return. The agronomic result agrees with the economic return obtained from the experiment.

2. The net benefits of EGOLF application with 200,400,600L ha^{-1} with Nafis varieties exceed than non-fertilized plots. The highest net benefit (1028185 ETB) was obtained from EGOLF applied with 200 L ha^{-1} followed by inorganic (200 NPSB+150 Urea kg ha^{-1}) fertilizer treated plots (962197.10 ETB) and the highest marginal rate of return was obtained from Nafis variety supplied with 200 L ha^{-1} EGOLF with the value of 2551.959% (Table 11). Relatively the lowest marginal rate of return was obtained from Nafis variety treated with no fertilizer with the value of 1718.826 ETB (Table 13). This implies that for every 1 ETB investment on the EGOLF on Nafis onion variety in Gorowertu kebele, earn additional 25.52 ETB economic return. The agronomic result agrees with the economic return obtained from the experiment.

3. The net benefits of EGOLF applied with 200,400,600 L ha^{-1} with Nasik varieties exceed those of non-fertilized plots. The highest net benefit (835454.10 ETB) was obtained from inorganic fertilizer treated with (200 NPSB+150 Urea kg ha^{-1}) and the lowest net benefits were obtained from the control with the value of (321693 ETB). The highest marginal rate of return was obtained from the Nasik variety supplied with inorganic fertilizer (200 NPSB+150Urea kg ha^{-1}), with the value of (2155.72%). This implies that for every 1 ETB investment in inorganic fertilizer, an additional 21.56 ETB economic return of the Nasik onion variety in the Gorowertu peasant association.

Table 9. Partial budget analysis of onion as influenced by Eco green fertilizer rates in Debere-Libanos district.

Treatment Names	Treatment combinations	Fertilizer cost/ha (ETB)			LC for harvesting	cost of bag	Transport cost	TVC
		Eco green	NPSB	Urea				
T11	Nasik x 0 L ha^{-1} EGOLF	0	0	0	2345.68	1671.3	8550	12566.98
T1	Robaf x 0 0 L ha^{-1} EGOLF	0	0	0	2749.26	1958.9	11050	15758.11
T6	Nafis x 0 0 L ha^{-1} EGEG	0	0	0	3222.95	2296.4	13950	19469.30
T13	Nasik x 200 0 L ha^{-1} EGOLF	14000			5864.21	4178.3	14600	38642.46
T12	Nasik x (200 NPSB+150Urea) kg ha^{-1}		7000	9000	6146.53	4379.4	13900	40425.93
T3	Robaf x 200 L ha^{-1} EGOLF	14000			6874.11	4897.8	15500	41271.91
T2	Robaf x (200 NPSB+150 Urea) kg ha^{-1})		7000	9000	6517.89	4644	14300	41461.89
T8	Nafis x 200 L ha^{-1} EGOLF	14000			7529.68	5364.9	17900	44794.58
T7	Nafis x (200 NPSB+150 Urea) kg ha^{-1}		7000	9000	7067.37	5035.5	16800	44902.87
T14	Nasik x 400 L ha^{-1} EGOLF	28000			5790.32	4125.6	13750	51665.92
T4	Robaf x 400 L ha^{-1} EGOLF	28000			5860.42	4175.6	13900	51935.97
T9	Nafis x 400 L ha^{-1} EGOLF	28000			6798.32	4843.8	16150	55792.12
T15	Nasik x 600 L ha^{-1} EGOLF	42000			5631.16	4012.2	13350	64993.36
T5	Robaf x 600 L ha^{-1} EGOLF	42000			5794.11	4128.3	13750	65672.41
T10	Nafis x 600 L ha^{-1} EGOLF	42000			6027.16	4294.4	16350	68671.51

EGOLF = Eco green organic liquid fertilizer

When we compare the three varieties from the economic feasibility point of view: - Robaf and Nafis with 200L ha^{-1} EGOLF, Nasik with (200 NPSB+150 Urea kg ha^{-1}) in organic fertilizer, Nasik with 200 L ha^{-1} EGOLF ranks 1st, 2nd, 3^{rd,} and 4th level. Therefore. The net benefit and benefit cost ratio estimated for 15 treatments are presented in Table 12 and Appendix Table 3, respectively. The application of 200 L ha^{-1} EGOLF had the highest net benefit of 1028185 ETB ha^{-1}, while the lowest net benefits of 321693 ETB ha^{-1} were recorded from the non-fertilized treatment. The control treatment that had the lowest costs to the last treatment, which had the highest cost that varies; the marginal rate of return obtained was above the minimum acceptable marginal rate of return (Table 13 and Appendix Table 4). Accordingly, this study revealed that the application of 200 L ha^{-1} EGOLF was the best recommendation for treatments subjected as the marginal rate of return was not necessary based on the highest value or MRR; rather, based on the minimum acceptable MRR becomes the initial recommendation (CIMMYT, 1990). The process of calculating the MRR of alternative treatments proceeds in steps from the least costly treatment to the most costly, and resolves if they are acceptable to farmers, which is called marginal analysis (CIMMYT, 1990). In this study, 100% was considered as minimum acceptable rate of return for farmers' recommendation.

Table 10. Partial budget analysis of onion as influenced by eco green organic liquid fertilizer rate in Debre- Libanos district.

Treatment Names	Treatment combinations	TVC	MBY (t/ha)	Adjusted MBY(t/ha)	Gross income (ETB)	Net income (ETB)	ND/D
T11	Nasik x 0 L ha^{-1} EGOLF	12566.98	12.38	11.142	334260	321693	ND
T1	Robaf x 0 L ha^{-1} EGOLF	15758.11	14.51	13.059	391770	376011.9	ND
T6	Nafis x 0 L ha^{-1} EGOLF	19469.3	17.01	15.309	459270	439800.7	ND
T13	Nasik x 200 L ha^{-1} EGOLF	38642.46	30.95	27.855	835650	797007.5	ND
T12	Nasik x ((200 NPSB+150 Urea) kg ha^{-1}	40425.93	32.44	29.196	875880	835454.1	ND
T3	Robaf x 200 L ha^{-1} EGOLF	41271.91	36.28	32.652	979560	938288.1	ND
T2	Robaf x (200 NPSB+150 Urea) kg ha^{-1}	41461.89	34.4	30.96	928800	887338.1	D
T8	Nafis x 200 L ha^{-1} EGOLF	44794.58	39.74	35.766	1072980	1028185	ND
T7	Nafis x (200 NPSB + 150 Urea) kg ha^{-1}	44902.87	37.3	33.57	1007100	962197.1	D
T14	Nasik x 400 L ha^{-1} EGOLF	51665.92	30.56	27.504	825120	773454.1	D
T4	Robaf x 400 L ha^{-1} EGOLF	51935.97	30.93	27.837	835110	783174	D
T9	Nafis x 400 L ha^{-1} EGOLF	55792.12	35.88	32.292	968760	912967.9	D
T15	Nasik x 600 L ha^{-1} EGOLF	64993.36	29.72	26.748	802440	737446.6	D
T5	Robaf x600 L ha^{-1} EGOLF	65672.41	30.58	27.522	825660	759987.6	D
T10	Nafis x 600 L ha^{-1} EGOLF	68671.51	31.81	28.629	858870	790198.5	D

Table 11. Cost-benefit analysis of onion as influenced by eco-green organic liquid fertilizer rate in Debre—Libanos district.

Treatment Names	Treatment combinations	TVC	Gross income (ETB)	Net income (ETB	ND/D	CVC	CNB	MRR%
T11	Nasik x 0 L ha^{-1} EGOLF	12566.98	334260	32169	ND			
T1	Robaf x 0 L ha^{-1} EGOLF	15758.11	391770	376011.9	ND	3191.13	54318.87	1702.18
T6	Nafis x 0 L ha^{-1} EGOLF	19469.3	459270	439800.7	ND	3711.18	63788.82	1718.83
T13	Nasik x 200 L ha^{-1} EGOLF	38642.46	835650	797007.5	ND	19173.16	357206.8	1863.06
T12	Nasik x (200 NPSB+150 Urea) kg ha^{-1}	40425.93	875880	835454.1	ND	1783.47	38446.53	2155.72
T3	Robaf x 200 L ha^{-1} EGOLF	41271.91	979560	938288.1	ND	845.98	102834	12155.62
T8	Nafis x 200 L ha^{-1} EGOLF	44794.58	1072980	1028185	ND	3522.68	89897.32	2551.96

4.7. Correlation Analysis

The correlation analysis was conducted to evaluate the relationships between growth and yield parameters of onion Varieties as influenced by EGOLF and varieties. Accordingly, marketable yield of onion was significantly and positively correlated with plant height ($r=0.77^{***}$), number of leaves($r=0.78^{***}$), leaf length ($r=0.91^{***}$), leaf width ($r=0.62^{**}$), days to maturity($r=0.61^{**}$), above ground biomass ($r=0.53^{**}$), Dry mater of above ground biomass($r=0.50^{**}$), bulb weight($r=0.85^{***}$). Bulb length ($r=0.61^{**}$), bulb diameter($r=0.65^{**}$) and total bulb yield ($r=0.99^{***}$). On the other hand Marketable yield of onion was significantly and negatively correlated with unmarketable yield ($r= -0.0.29^{NS}$).

Generally, the correlation analysis result indicated that, the growth and yield parameters such as plant height, leaf number, leaf length, leaf width, above ground biomass, bulb weight, bulb length and diameter linearly contributed for the improvement of marketable yield and as well as total yield by using EGOLF and onion varieties. This shows that positively correlated parameters analysis improved marketable yield while negatively correlated parameter analysis decreased marketable yield, as indicated by Yeshwas *et al* (2018). Therefore, EGOLF and varieties under this experiment optimized the yield of onion.

Table 12. Correlation analysis

Variable	PH	LN	LL	LW	DM	DMAGBM	AGBM	BW	MBY	UMBY	TBY	BL	BD
PH	1												
LN	0.66**	1											
LL	0.76***	0.85***	1										
LW	0.57**	0.53**	0.56**	1									
DM	0.50**	0.65**	0.58**	0.26NS	1								
DMAGBM	0.55**	0.57**	0.55**	0.48**	0.31*	1							
AGBM	0.57**	0.61**	0.58**	0.49**	0.33*	0.99***	1						
BW	0.74***	0.67**	0.79***	0.47**	0.51**	0.35*	0.37*	1					
MBY	0.77***	0.78***	0.91***	0.62**	0.61**	0.50**	0.53**	0.85***	1				
UMBY	0.06NS	0.26NS	0.26NS	0.13NS	0.26NS	0.10NS	0.11NS	0.24NS	0.29NS	1			
TBY	0.76***	0.78***	0.91***	0.61**	0.62**	0.50**	0.52**	0.85**	1.00***	0.32	1		
BL	0.58**	0.47**	0.55**	0.75***	0.19NS	0.53**	0.54**	0.50**	0.61**	0.17	0.61*	1	
BD	0.59**	0.48**	0.51**	0.74***	0.46*	0.38*	0.39*	0.52**	0.65**	0.06	0.64*	0.69*	1

PH=Plant height; LN=Leaf Number; LL=Leaf Length; LW=Leaf width; DM=Days to Maturity; DMAGBM=Dry Weight of above Ground Biomass; BD=Bulb Diameter; BW=Bulb Weight; BL=Bulb Length; AGBM=Above Ground Biomass; MBY=Marketable Bulb Yield; UMBY=Unmarketable Bulb Yield, TBY=Total Bulb Yield; *, **, *** and ns = correlation is significant at $\rho < 0.05$, 0.01, 0.001 and non-significant, respectively.

5. CONCLUSION AND RECOMENDARION

5.1. Conclusion

This field experiment was conducted to determine the effect of EGOLF rate on growth, yield components, and yields of onion varieties, the best performing improved onion variety, and economically optimal rate of EGOLF for onion production under irrigation, which has not been studied farther in the study area and even in our country before. According to the findings obtained, EGOLF has shown a 143.75% increment in marketable bulb yield and 137.83% in total bulb yield over the control at the rate of 200 lit ha^{-1}. This result showed promising evidence to increase onion productivity and production in the study area compared to the control and was statistically similar to the recommended inorganic fertilizer (NPSB + urea). EGOLF significantly promoted root and aboveground growth of onion plants by increasing the uptake of macro and micronutrients compared to mineral fertilization, and is short-acting. The plant growth was rapid when essential nutrients were available in sufficient quantities. On the other hand, Maximum yield was recorded, 33.23 and 30.32 t ha^{-1} from Nafis and Robaf varieties, respectively. This result also showed that Nafis was the highest yielder from the three varieties, but Robaf was the most economically feasible variety in the study area, at the rate of 200 L ha^{-1}, which showed 12155.62% MRR.

5.2. Recommendation

Organic liquid fertilizer can be used as an alternative to inorganic fertilizer, leading to higher crop yields, even better than the yield of inorganic fertilizer. It has no adverse side effects, improving both the physical and biochemical properties of the soil. It will also have the potential to save the country foreign currency it spends to import fertilizer, and can improve the problem of scarcity of supply. On the other hand, EGOLF may not solve the problem of soil nutrients for all types of soils and it needs water in bulk. So, further research is also needed to use in combination with inorganic fertilizer.

Finally, this study was conducted at one place for a single season and has to be conducted in multiple locations across similar agro-ecology for sound recommendations than the present study for end users and front-line extension workers.

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7. APPENDICES

Appendix I. ANOVA Table of phenological and growth parameters

Source of variation	DF	Mean square						
		DM	PH	LN	LL	LW	AGBM	DMAGBM
Replication	2	0.6^{ns}	7.129^{ns}	4.140**	2.22^{ns}	0.040562^{ns}	117.55^{ns}	0.5968^{ns}
Eco green	4	371.72***	129.987***	32.835***	448.80***	0.142719**	760.64**	3.2490**
Variety	2	31.27*	74.625**	4.193**	11.80***	0.127896*	781.98**	3.4081*
Eco green x Variety	8	2.82^{ns}	3.738^{ns}	1.807*	2.56**	0.008362^{ns}	46.80^{ns}	0.2056^{ns}
Error	28	7.67^{ns}	8.756^{ns}	0.673^{ns}	0.99^{ns}	0.025234^{ns}	133,.71^{ns}	0.6467^{ns}

ns= not significant, *= significantly influenced at(p<0.05), **= highly significantly influenced(p<0.01), ***= very highly significantly influenced at(p<0.001).

Appendix II. ANOVA Table of yield parameters

Source of variation	DF	Mean square					
		BL	BD	ABW	MBY	UMBY	TBY
Replication	2	0.1153	0.7247^{ns}	399.31^{ns}	4.47	0.008847^{ns}	4.69^{ns}
Eco green	4	3.2488***	5.0624***	2527.94***	666.39***	0.138036 ^{ns}	677.54***
Variety	2	3.1083**	6.7734***	826.88**	99.91***	0.141140 ^{ns}	103.11***
Eco green x Variety	8	0.2663^{ns}	0.3483^{ns}	59.86^{ns}	5.67^{ns}	0.130854 ^{ns}	6.03^{ns}
Residuals	28	0.4016^{ns}	0.5749^{ns}	144.97^{ns}	10.18^{ns}	0.065835^{ns}	10.63^{ns}

ns= not significant, *= significantly influenced at(p<0.05), **= highly significantly influenced(p<0.01), ***= very highly significantly influenced at (p<0.001.

Agronomic practice Field activity pictures

Figure 2.Seed bed preparation, seed sowing and shade construction.

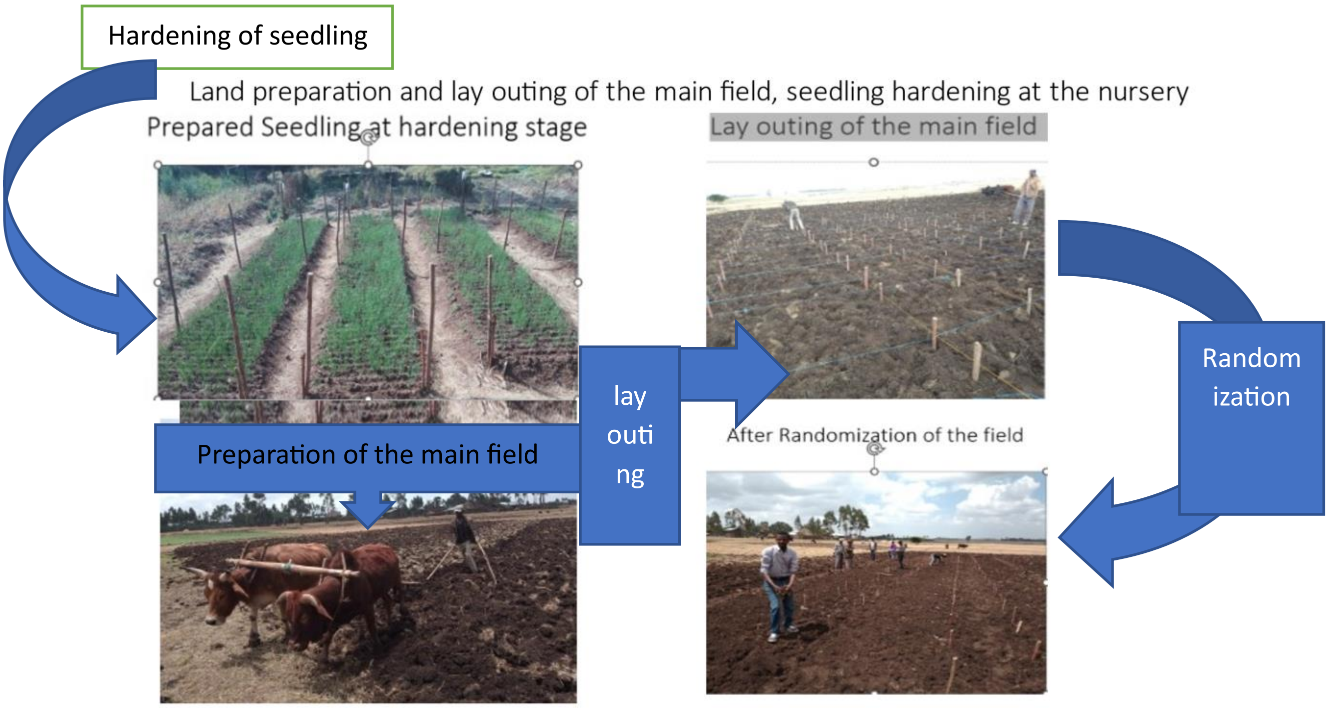

Figure 3. Seedling hardening, land preparation and lay outing.

Figure 4. Seedling selection, furrow ridge preparation, planting seedlings and entertaining lunch at the field level.

Transplanted seedling establishment (Robaf=96.33, Nafis=96.89, Nasik=96.44, Total average =96.56%) before replacement.

Figure 5. Established seedling inventory result.

Each plots are labeled according to its treatment when Eco green application is done with hand sprayer

Figure 6. EGOLF spraying with hand sprayer.

Figure 7. Field follows up.

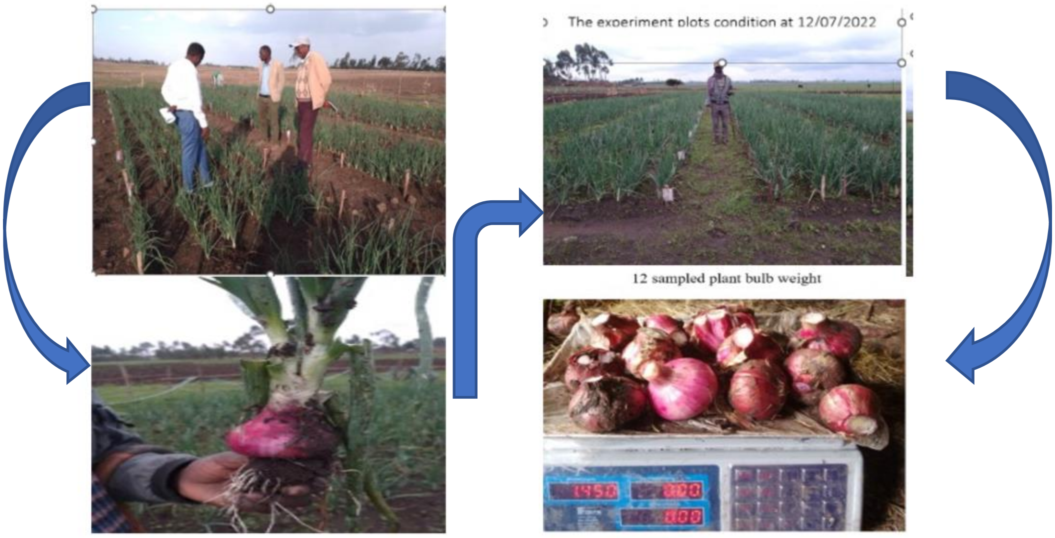

Figure 8. Field supervision by advisors, observations and data collections.

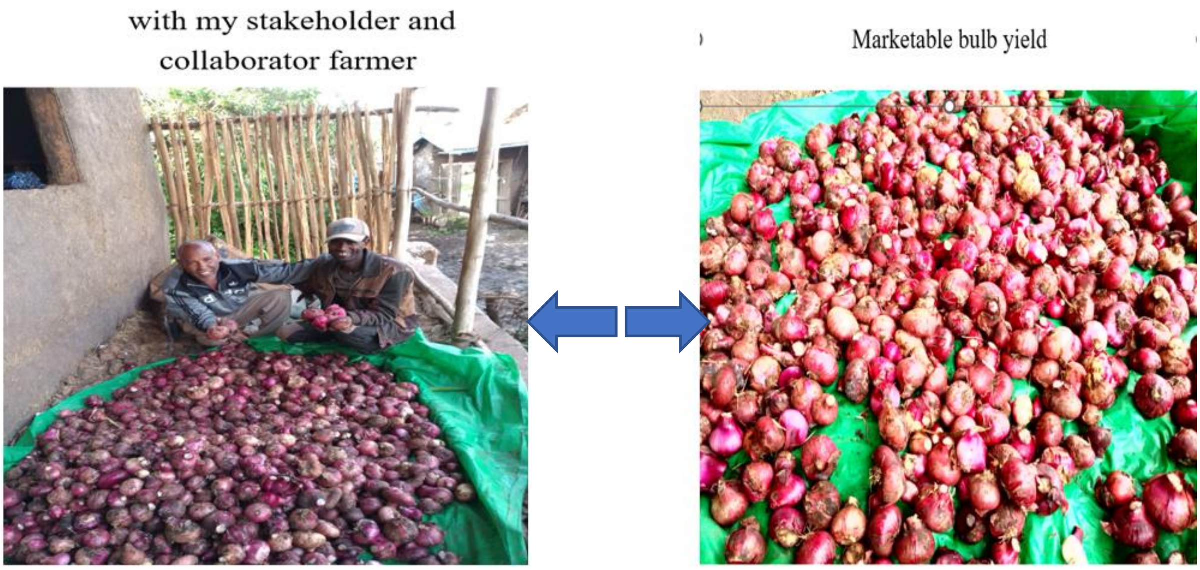

Figure 9. Marketable yield produce