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"BioBoost", the Subtle Gem of EIAR's Technological Bonanza

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One of the earliest accounts of the conversion of a compound into a product appears in the 'Holy Bible' whereby Jesus turned water into wine. With no mention of the use of starter cultures and the involvement of organic compounds, one would assume that the conversion of water into wine at that time was possible through divine intervention. In today's world, however, wine making certainly involves the use of microbial starter cultures in a process called fermentation. Biologists describe the term fermentation as a biochemical process by

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various bacteria, fungi, and the enzymes they produce that breaks down organic materials to produce energy and simpler compounds. People has been harnessing this transformative power of microbes to produce alcohol, to preserve food, to make it more digestible, less toxic, and/or more delicious.

In the 19th century, Louis Pasteur, French chemist, pharmacist, and microbiologist renowned for his discoveries of the principles of pasteurization, vaccination, and microbial fermentation proposed that fermentation occurs due to the presence of microorganisms. By definition, microorganisms, including bacteria and yeast, are small living cells that cannot be seen with the naked eye. Pasteur also found out that different bacteria perform different types of fermentation. As a result, it is possible to obtain various end products. Because cells in our body are capable of fermentation, we know that fermentation is a natural phenomenon much broader than human culinary practices.

With its ancient roots, one word that comes to the fore in the process of fermentation is culture. The starters we add to milk to initiate fermentation and make cheese are called, starter cultures. As one of the oldest nations in the world, Ethiopia possesses distinct tradition of fermenting food and drinks. The traditional (cottage) and modern milk processing are the two milk processing systems practiced in Ethiopia. The traditional milk processing is dominantly practiced in which milk is processed into various products such as butter, cottage cheese, whey and fermented milk. Customarily, Ethiopians have been using yeast and or lactic

acid bacteria for fermentation by letting animal milk, tef dough, and wort in their respective containers for days. This process is characterized by the use of back slopping and slow fermentation time.

From Injera and Enset preparations to cheese making, the use of back slopping is common. However, these traditional fermentation takes much of family time, is laborious and final products are often inconsistent. Modern dairy processing includes businesses that deal in the collection, processing, packaging, treating, cutting or manufacturing of dairy products, and the packing and storing of those products on the premises where they are processed. Ethiopia's modern dairy processing sector is growing fast with more dairy processing companies flourishing in different parts of the country.

The last month of the year 2024 memorably marked the beginning of a new era for the Ethiopian Institute of Agricultural Research as it colorfully launched the "BioBoost" project. Bio-Boost, shorthand for 'Bioinoculant Technology Solutions for Sustainable Bioeconomy in Ethiopia is a collaborative project between EIAR, BETin, Arbaminch University, Sebeta Agro Industry PLC and is financially supported by the International Centre for Genetic Engineering and Biotechnology (ICGEB). The overall goal of the project is to produce standardized commercial quality lactic acid bacteria (LAB) and Yeast starter cultures for sustainable industrial and community use by strengthening the national capacities on commercial production and marketing of local starter culture technologies and Enset processing machines through public private partnership (PPP).

This ICGEB funded BioBoost project was officially launched on the 12th of January 2024. The total value of the project is 400,000 euros for two years. Microbial biotech researchers from NABRC, relevant stakeholders from other institutions and the private sector attended the launching ceremony. In his opening remarks, Professor Nigussie Dechassa (DG, EIAR) said that he is excited about the BioBoost project as

Fig. 1 Participants of the BioBoost Project launching Meeting

it brings together key partners, aspires to deliver locally developed starter culture technologies, and as it promises to strengthen national capacities in commercial production and marketing of local starter culture technologies through public private partnership.

Since its establishment, the microbial biotech team at NABRC was working hard to isolate the LAB and yeast starter culture technologies. Promising isolates were meticulously tested for key parameters required by the dairy processing companies. At last, a comparative assessment was conducted using imported starter culture technologies under industrial scale at the three major dairy processing companies in Ethiopia. Our LAB starter technology shows outstanding performance compared to the imported starter cultures making it the best candidate for scaling up and commercialization in Ethiopia and beyond.

The launching was graced by the following speakers: Professor Nigussie Dechassa (DG, EIAR), Dr. Diriba Geleti (DDG, EIAR), Dr. Emanuel Burratti (Scientific Coordinator, ICGEB), Professor Kassahun Tesfaye (DG, BETin), Dr. Dejene Girma (Director, Biotech Research, EIAR), Mr Mulugeta Yimer (CEO, Sebeta Agro Industry PLC), Mrs Elena Benedtti (Head, Fundraising, Technology Transfer and Innovation, ICGEB), Professor Firew Mekbib (Haramaya University), Mr Mulatu Workie (Program Leader, Microbial Biotech Research, EIAR).

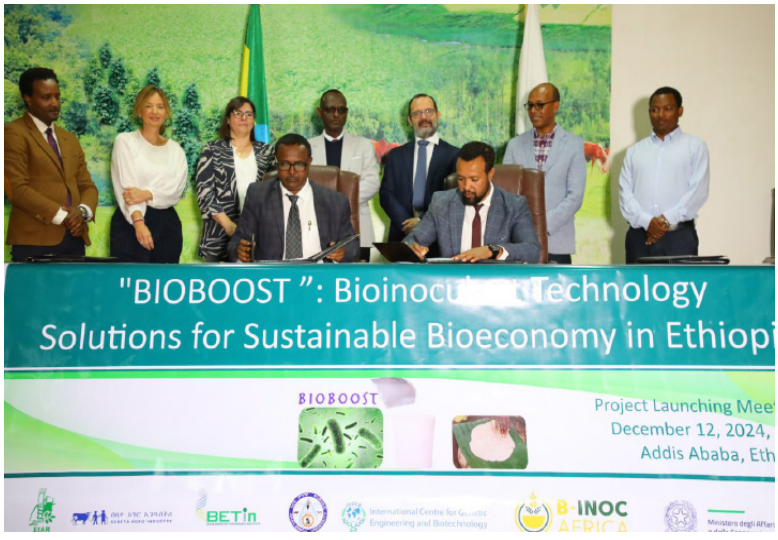

Fig. 2 EIAR and Sebeta Agro Industry PLC signing MoU

Commercialization of biotechnology products is the process of turning scientific discoveries into products or services that are available to the general public. The agricultural biotechnology research directorate recognizes that there are challenges to commercial challenges to commercialization while moving its biotech products from the lab tothe market. In Ethiopia, policies aimed at facilitating technology transfer exist in the larger context. In an effort to facilitate the commercialization of its scientific research outputs and design methods of technology transfer to the private sector, EIAR has already developed institutional commercialization guideline.

There is no doubt that BioBoost will help unlock future economic value from biotechnology research at EIAR. Also, it will stimulate the creation of biotech startups through licensing arrangements. Suffused with its unique institutional cultural imperatives to work well for the public good, we believe that EIAR will see the financial value of its biotechnology research wing through the BioBoost project which has just made the wall between research and commercialization porous and became the subtle gem of its technological bonanza.

The Ethiopian Institute of Agricultural Research Hosted the 4th Decadal Maize Workshop from 29-31st August, 2024 at its Headquarter

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Background

Maize is the leading cereal crop in Ethiopia in terms of the total number of farmers growing it, total annual production, and yield harvested per unit area. Between 1961 and 2022, the total production of maize in Ethiopia increased from 0.727M tons to 10.2M tons while the average national yield increased from 0.96 to 4.2 t ha-1. Though many factors contributed to the drastic increase in the production and productivity of maize, research will take the lion's share of contributions. The maize research is agro-ecology based, whereby germplasms have been developed targeting four broadly classified major agro-ecological zones of Ethiopia, viz., mid-altitude sub-humid (1000-2000 meters above sea level [m.a.s.l.]), highland sub-humid (1800-2600 m.a.s.l.), lowland moisture stress areas (250-1500 m.a.s.l.), and lowland sub-humid (<1000 m.a.s.l.) with testing stations strategically located throughout the country. Since the start of maize research in Ethiopia in the 1950s, four consecutive decadal workshops were conducted by the national maize research project/program of the Ethiopian Institute of Agricultural Research, aiming to review the past decade's achievements, including new technologies developed and challenges on maize research and development endeavours and design the way forward. Many useful technologies have been generated and efforts have been made to transfer these technologies to users. Information on these improved technologies are scattered in different progress reports or published papers and are not readily available to users, researchers, and policy makers. The objectives of the fourth decadal (2012-2021) workshop were, therefore, to: • Pool together the available but scattered information and make it usable for the research clients, • Assess the role and importance of maize along the value chain in the Ethiopian economy, • Bring together all stakeholders involved in maize production and research and collate research results and their impact, • Identify opportunities for research and set priorities among them. The workshop theme was: *"Harnessing maize genetics and management practices to revitalize the Ethiopian food system in the face of climate change"*.

Contents of the workshop

The workshop participants were stakeholders and partners from varied maize research and development backgrounds and invited dignitaries. More than 220 participants attended the workshop, which lasted for three days and covered seven review sessions. Four keynote speeches were made by the dignitaries and senior research scientists. Simultaneously, exhibitions were also prepared to showcase maize technologies and agricultural machineries (Fig. 1). The exhibition of maize technologies enriches the workshop by providing a tangible, real-world dimension to the research discussions and fostering collaboration among participants. In addition to four keynote addresses and an opening speech, 39 papers covering a wide array of disciplines, including breeding and genetics, agronomy and climate-geospatial, maize protection (pathology, entomology, and weed science), maize economics and agricultural extension, maize seed research and technology multiplication, maize utilization and farm implements/ machineries) were presented at the workshop. Representatives from international organizations and partner institutions such as CIMMYT, Corteva Agriscience PLC, Sasakawa African Associations, and others were invited and presented papers on topics of mutual interest.

Fig. 1 Workshop and Exbition of Maize Technology and Agricultural Machineries

Major Activities undertaken at the event

The workshop was commenced by a welcome address of the former Director General of EIAR, H.E. Dr. Feto Esimo and followed by an opening speech of the state Minister of Agriculture and Horticulture, H.E. Dr. Melese Mekonnen. H.E. Dr. Melese in his speech, said, *"I recognize the importance of such a kind of conference that brings all actors in the maize value chain, and I believe that the engagement among the public, private, and other relevant partners will help to create synergy and bring impact and should be strengthened also on other important commodities"*. Dr. Prassana, the CIMMYT Global Maize Director, in the keynote address, explained that climate change, extensive malnutrition, a fragile natural resource base, biodiversity loss, plant health threats, and the need to achieve food and nutritional security within the planetary boundaries all necessitate a paradigm shift in our approach to agriculture. Dr. Mosisa Worku, the former National Maize Program Coordinator and Seed System Specialist at CIMMYT-Kenya, on

the other hand, pinpointed in his keynote address that the uptake and success in commercialization of new maize hybrids by seed companies depend on the entire quality of the parental inbred lines and at each stage of early generation seed production and certified seed production of the hybrid.

It was clearly shown from the maize breeding and genetics session of the workshop that breeding has significantly contributed to the increase in production and productivity of maize in Ethiopia. Considering the EIAR's intermediate maturity breeding pipeline, which has been utilizing inbred lines generated from EIAR and CIMMYT source germplasm, a positive genetic trend of 91 kg ha^{-1} year^{-1} (1.4%) was observed for grain yield in the hybrids. Similarly, a positive genetic trend of 72.6 kg ha-1year-1 (1.27%) was also attained for grain yield in intermediate to late maturity commercial hybrids. The genetic gain of the intermediate pipeline is higher than the genetic gain reported from similar national breeding programs in sub-Saharan Africa. These positive genetic trends are the result of continuous improvements and changes within the EIAR breeding programs, such as changes in breeding approaches and the use of stress tolerant elite germplasm.

These positive and significant genetic trends observed for grain yield in the last decade is translated into tangible benefits to smallholder farmers as manifested by increased national production and productivity in the country. Further gains are anticipated through the ongoing modernization of the breeding programs through refined product concept/profile-based breeding, new methods for inbred ine development, reduced breeding cycles, and lnew experimental designs and data analysis methods

Of course, the observed increase in production and productivity of maize was hardly possible without employing sustainable use of agricultural inputs such as seeds of improved varieties, fertilizers, and pesticides. In the past decade, the trend of agricultural input use for maize production has been increasing in all kinds of inputs except that of DAP, which was due to its replacement by NPS fertilizer. In the decade, on average 59% of the total cultivated maize area was planted to certified seed of maize and on average around 3 million holders used 272,340 quintals of improved seed annually (Fig. 2).

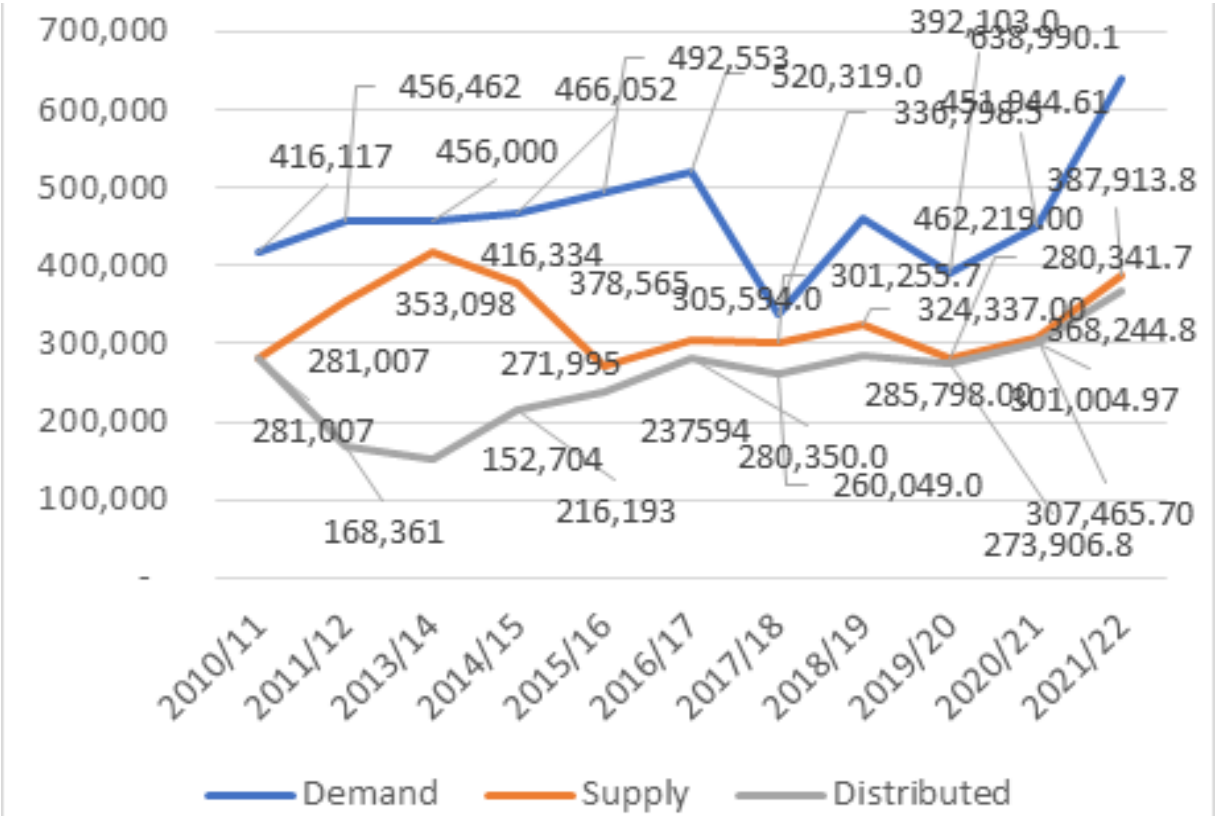

Fig. 2 Seed Demand, Supply and Distribution in Qt(source: MoA, as cited by Tefera et al., 2024

The chemical fertilizer use in the decade varies in kind and combination. On average basis, there were farmers who applied Urea only (441,516 holders/year), DAP only (936,756 holders/year), DAP+Urea (1,959,258 holders/year), NPS only (4,823,482 holders/year), NPS+Urea (2,968,113 holders/year). However, integrated use of soil management technologies (such as the integration of organic and inorganic fertilizers) can possibly reduce considerable quantities of inorganic fertilizers and economically save costs paid for chemical fertilizers in maize production. On average, 638,420 holders use pesticides on 177,968 ha of maize farms annually. Among others, the key challenges linked to agricultural input supply were limited and late delivery of seed, limited and untimely supply of fertilizers, and weak linkages among agricultural inputs providers.

Evidences revealed that the certified seed use by farmers from formal seed sources has positively influenced maize productivity in Ethiopia. Certified seed and fertilizer use, and other improved agronomic management practices are complementary agricultural inputs that can positively influence the maize yield. To enhance maize-certified seed use, there is a need to improve the access of farmers to fertilizer. Besides, certified seed use is associated with farmers' access to extension packages and services. Maize extension packages consider certified seeds as an important component of the menu (Fig. 3).

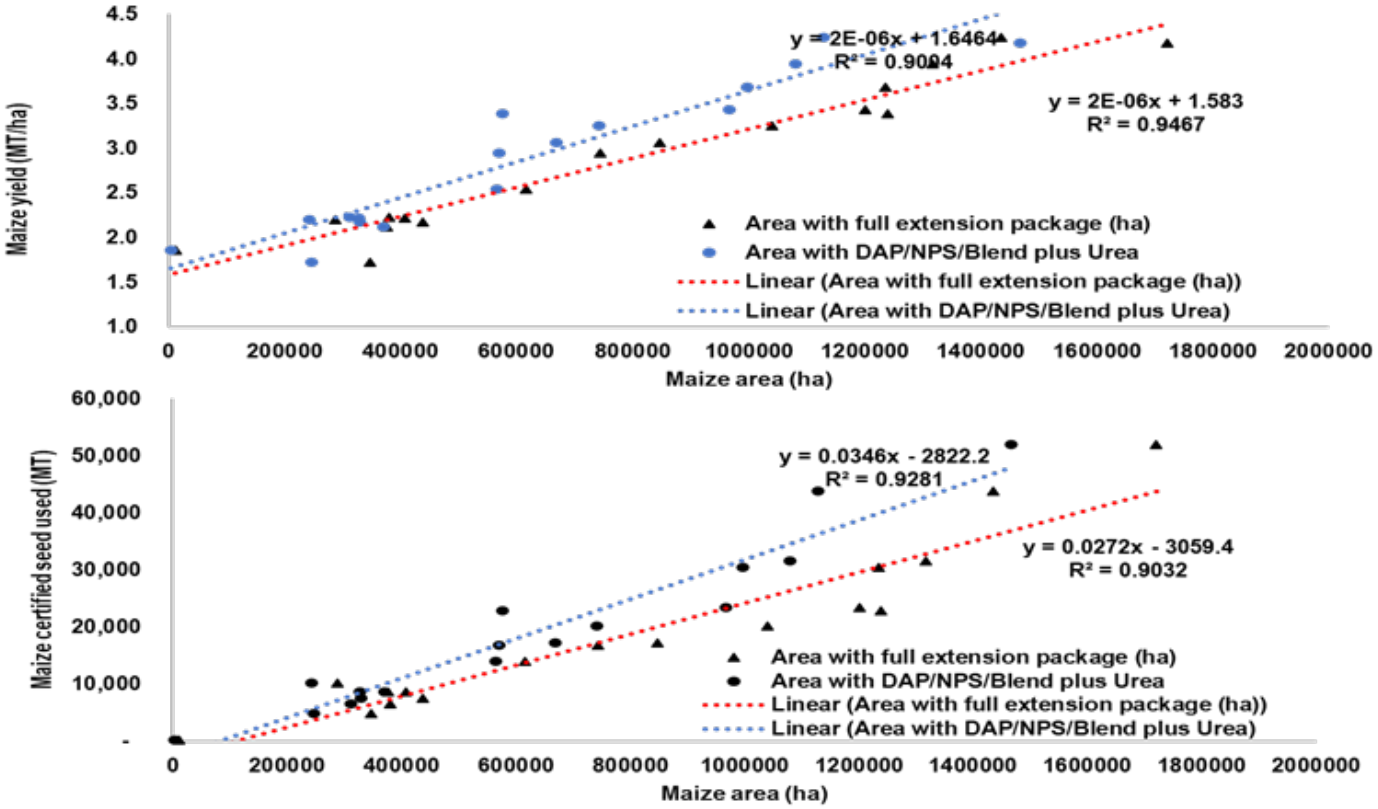

Fig. 3 The relationship between fertilizer use, use of extension packages, maize yield, and quantity of certified seed used between the years 2004 to 2021. (Source: http://www.statsethiopia.gov.et/our-survey-reports/, as cited by Karta et al., 2024- International Journal of Agronomy)

On the contrary, recurrent droughts and the increasing unpredictability of weather patterns due to climate change pose significant challenges to maize production. Ethiopia has experienced significant warming, with annual temperature rising between 0.12 and 0.54°C per decade, and projections indicate a further increase of 1.2 to 1.4°C by 2050, coupled with increasingly variable precipitation patterns. These climatic changes have resulted in water stress, pest proliferation, and reduced

yields. Post-harvest handling and storage are compromised by increased temperatures and humidity and thus experienced losses.

Conclusions and take-home messages

Maize is among top food security crops in Ethiopia. Extensive research and development works that had been done on the crop resulted in tangible impacts in the lives of many households in Ethiopia. However, the crop is still facing multiple challenges including, biotic and abiotic stresses. Therefore, coordinated approach is essential to build resilience, develop and promote climate-smart technologies and practices, and IPM strategies to control pests and diseases without relying heavily on chemical pesticides and enhance adaptive capacity across the maize value chain to ensure food security and sustainable development. Climate change challenges require region-specific adaptation strategies, including conservation tillage, nitrogen application, and mulching, which can enhance yields under varying climate scenarios. Strengthening existing farmer adaptation efforts through improved access to information, resources, financial support, and capacity building is crucial.

Finally, proceedings of the workshop, which is a valuable source of information for policy makers, researchers, agricultural experts and development agents, producers, planners, and others interested in improving maize production in this country will be published soon.

The Ethiopian Institute of Agricultural Research Engaged in Lowlands Livelihood Resilience Project-II for Advancing Livelihoods and Climate Resilience in Ethiopia's Pastoral and Agro-pastoral Regions

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Introduction

The Lowland Livelihoods Resilience Project (LLRP II) is an initiative aimed at enhancing the livelihoods and climate resilience of pastoral and agro-pastoral communities in Ethiopia's lowlands. This comprehensive development program is a collaborative effort between the Federal Democratic Republic of Ethiopia, the International Development Association (IDA), and the International Fund for Agricultural Development (IFAD), with a total investment of US$ 424 million. This funding includes USD 340 million from IDA, USD 80 million from IFAD, and USD 4 million contributed by beneficiary communities. The Ministry of Irrigation and Lowlands (MILLs) is the host and leading organization for the project.

The project spans 120 pastoral and agro-pastoral weredas across eight regional states: Somali, Afar, Benishangul-Gumuz, Gambella, South Ethiopia Region, Southwest Ethiopia Peoples' Region, Oromia, and Dire Dawa. In a significant development, the Ethiopian Institute of Agricultural Research (EIAR) has signed a Memorandum of Understanding (MoU) with MILLs on August 17, 2024. This partnership aims to provide critical support for the implementation of activities outlined in Component Three of the project over the next five years.

The MoU focuses on several areas of mutual interest:

- Coordination of Demonstration and Dissemination: Promoting climate-smart technologies and innovations through "smart packs."
- Multiplication and Provision of Agricultural Technologies: Facilitate the multiplication and provision of Agricultural Technologies

- Agro-Advisory Services: Offering expert guidance to pastoral and agro-pastoral communities.
- Targeted Trainings and Technical Support: Providing high-level training and support to enhance local capacities.

Fig 1- Project Launching Event

Recent Workshop Highlights

On December 10-11, 2024, EIAR organized a pivotal workshop in Adama aimed at identifying and prioritizing smart pack technologies. This event brought together senior researchers from EIAR, regional agricultural research Institutes (RARIs) and various universities working in pastoral regions, as well as experts from the Ministry of Agriculture and the Ministry of Irrigation & Lowlands. The workshop focused on developing operational guidelines for the demonstration and dissem ination of climate-smart technologies in project weredas. The LLRP II represents a significant step towards improving the livelihoods and resilience of Ethiopia's pastoral and agro-pastoral communities. With the collaborative efforts of EIAR, RARIs, Universities, MoA, CGIARs and MILLs, the project is poised to make a meaningful impact by enhancing pastoral livelihoods through promoting climate-smart agricultural technologies and innovations

Fig 2- Group discussion of participants

EIAR-BAASF Joint Initiatives:-Leading the Change in Agricultural Technology and Capacity Building Advancements in Ethiopia

Mekuria Tadesse (PhD) and Prof. Nigussie Dechasa (PhD)
Ethiopian Institute of Agricultural Research, Addis Ababa

In 2022, a significant milestone was achieved with a memorandum of understanding between the Foreign Economic Cooperation Center of China (FECC) and the Ministries of Agriculture of China and Ethiopia. This agreement promotes the "Chinese-Ethiopian Shared Vision Initiative," focusing on enhancing agricultural technology, research, and education. Following this MOU, the Ethiopian Institute of Agricultural Research (EIAR) and the Beijing Academy of Agriculture and Forestry Sciences (BAASF) are collaborating to strengthen agricultural research and capacity building, supported by the FECC and the Ethiopian Embassy in Beijing. The FEEC organized a visit sponsored by BAASF from December 22 to 27, 2024, to extend the signed MOU. The purpose was to observe BAASF's capacities and research infrastructures and hold kick-off meetings. The visiting team from EIAR included General Director Prof. Nigussie Dechassa Robi and Dr. Mekuria Tadesse, head of the research system coordination office.

The visiting team could learn valuable lessons from BAASF, which operates 13 research institutes and 2 centers focused on five key areas: agricultural biology and genetic breeding; sustainable agricultural development; intelligent agriculture and digital villages; nutrition and health of agricultural products; and rural revitalization. Founded in 1958, BAASF employs 1,230 staff, including 574 senior professionals and 558 with doctoral degrees.

Among the visited research facilities, the maize research institute, established 27 years ago, boasts a dedicated team of 16 specialized professors, 22 assistant professors, 32 PhD holders, and 25 MSc research scientists. They have developed an impressive 200 maize varieties, playing a vital role in advancing agricultural and economic development in China. The hybrid wheat research institute, working with 7,000 germplasm, has pioneered double haploid wheat varieties, driving genetic gains by over 50% compared to classical varieties, and making a global impact in countries like South Africa, Kenya, and Pakistan. The vegetable research institute (BVRC), home to 100 scientists and remarkable AI-powered greenhouses across a 10ha area has released 400 vegetable varieties, ensuring food and nutrition security. Furthermore, the BAASF, part of the Beijing City government, proudly stands as the second-best Agricultural Sciences innovation organization in China, extending its impacts to over 32 countries around the world.

Demonstrations of various research activities were showcased to the visiting team, highlighting projects such as the design and implementation of AI-driven vegetable farming, real-time phenotyping of 300 lettuce varieties, intelligent soilless farming for spinach, trials of man-made soil profile employed for vegetable farming, intelligent soilless lilac cultivation, a combined farming system integrating strawberries and beekeeping, AI-enabled agrochemical sprayers, and robotic fruit harvesting, among others. Furthermore, professors conducted lectures within a greenhouse environment, which enriched the educational experience. The sessions focused on contemporary agricultural research, highlighting the recognition of AI-based solutions and skills as vital components for organizations that prioritize

creation, adoption, and dissemination to end-users. These tools not only aid decision-making processes but also function as fundamental elements that need to be incorporated with talent development to ensure accurate and dependable design, implementation, measurement, evaluation, and technology transfer throughout the agricultural research value chain. Thus, the visiting team obtained insights into AI-driven solutions that aid in expediting Ethiopia's 10-year agricultural development strategy, with the Ethiopian Institute of Agricultural Research (EIAR) playing a crucial role in meeting these national objectives. The sharing of knowledge between BAASF and the Ethiopian Agricultural Research System (EARS), particularly EIAR, provided valuable insights.

The EIAR leaders, represented by Prof. Niguissie Dechassa, DG EIAR, presented "Current Situation and Technological Needs of Ethiopian Agriculture" to highlight the roles of EIAR and its collaboration with BAAFS. The presentation covered agriculture in the tropics, drivers of transformation, and the Ethiopian government's agricultural initiatives. Key achievements, challenges, and opportunities of the National Agricultural Research System were discussed. Subsequently, Mekuria Tadesse, PhD, from the Research System Coordination Office, outlined potential areas for future collaboration with BAAFS.

Fruitful discussions were held with His Excellency the President of BAASF, Prof. Jiye Yan, and Vice President Xiaojun Guo at his office. The president warmly welcomed the visiting team and provided a brief overview of the academy, highlighting its areas of excellence, capabilities, achievements, and success stories. He also suggested potential areas for collaboration, focusing on the development of commodity research products and services. This includes exploring the establishment of bilateral research laboratory facilities, talent development, and the sharing of professional experiences between the two parties. The president opened the forum for detailed discussions to identify areas of mutual agreement among their scientists regarding future collaboration, which was effectively deliberated.

Delegates from BAASF and FECC convened at the Ethiopian Embassy in Beijing, under the leadership of His Excellency Ambassador Mr. Tefera Derbew. They engaged in decisive discussions to advance Agricultural Technology Cooperation, specifically targeting Agricultural Science, Research, and Education. Ambassador Tefera firmly stated that agriculture is the Ethiopian government's top priority, and critical to driving economic growth. He underscored the significance of collaborating with Chinese organizations and expressed appreciation for establishing this vital partnership. The ambassador commended both institutions for their unwavering commitment to signing a Memorandum of Agreement (MOA) within the frameworks of FOCAC and BRI, affirming the embassy's strong dedication to developing this collaboration for the mutual benefit of both nations.

Green Solutions for Treating Polluted Rivers: Application of Constructed Wetlands for Small Localities

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Background and justification

Freshwater scarcity resulting from rapid population rise and economic growth is now a global crisis (David et al., 2022). The urban population of Addis Ababa and its surrounding is growing quickly reaching 5.704 million (United Nations- World Population Prospects, 2024) and is expected to rise- for example it increased by 4.45% from 2023. It is obvious that urban dwellers are very demanding of the service level of the water and sanitation infrastructure. In many countries, sewerage systems are the preferred

solution to conveying waste water out of urban areas. However, only a small percentage of the recollected waste water receives treatment before it is released into the nearby rivers but most of the wastes (both liquid and solid) are directly released into the rivers without any treatment (Fig. 1). The fact that only a small percentage of waste water is being treated has negative impacts on the river's ecosystems and leads to environmental degradation. Moreover, the reuse of raw waste water mainly for vegetable production in Addis Ababa and its surrounding (a common practice that seemed perceived right by those who are practicing as well as using the products) could pose severe health risks for farmers, their families, and consumers of contaminated vegetables. A recent survey indicated that Vegetable production has been one of the important components of urban agriculture in Addis Ababa. About 248, 536 users and 1478 institutions were involved in vegetable production using rivers in the 2022 (Tolesa Alemu et al., 2024).

Waste water treatment can be an effective way to protect the environment and public health, especially when waste water is reused for crop production. Treatment systems based on natural degradation processes, such as stabilization ponds and constructed wetlands, are particularly suited for domestic waste water treatment where sufficient land is available, because they require little or no energy, are relatively simple to operate, and show reliable treatment performance

Constructed wetlands (CW) are natural waste water treatment systems (USEPA, 2000) designed to maximize the removal of waste water contaminants. Constructed wetlands are natural treatment systems that offer a variety of advantages that make them suitable for small to medium-size communities and they are cost effective in developing countries (Denny, 1997). There are three types of constructed wetlands used in treating wastewaters. These are surface flow constructed wetland, subsurface horizontal flow constructed wetland and vertical flow constructed wetland (the one used in our experiment, Fig. 1). They generally consist of layers of different size filter media and beds of aquatic macrophytes or wetland plants (Fig. 1). They differ from one another in system layout, the removal efficiency of certain pollutants, area requirements, technical complexity, applications, and costs (Gauss, 2008).

Source of waste water and type of constructed

Table 1. Characteristics of the wastewater at the source

Parameters	Measurements (source)
Dissolved oxygen	1.73
PH	6.2
Conductivity	1616.7
Total suspended solids	910
Total dissolved solids	508
Nitrate	30.71
Ammonium	3.67
Total phosphorus	13.38
BOD5	175
Total coliforms	1.04*104

wetland used

Wastewater was collected from Sebeta River (08° 45′ 964″ N, 38° 38′136″ E) flowing near the constructed wetland site that receives domestic and industrial wastes (Table 1), from the local residents and alcohol factory located about 0.5 km above the site. Vertical sub surface flow type of CW was used for the experiment (Fig 1).

The vertical flow type of constructed wetland, developed as an alternative to the Sub surface horizontal flow constructed wetland, consists of shallow sand filter beds and has higher oxygen transfer capacity (Alexandros et al., 2014). A distribution system on the surface of the constructed wetland allows the waste water to percolate vertically through the unsaturated filter bed. Plants support the vertical drainage process. An important feature of this type is the intermittent hydraulic loading with resting intervals between the single discharges to the vertical bed. This intermittent loading provides an effective aeration mechanism because pores of the filter bed refill with oxygen during the intervals. As a result, high nitrification rates can be achieved in the filters. Our result on the removal efficiencies of the treatments are well within the range from literature (Table 2). For

example Sandeep et al. (2021) reported that the contaminant removal efficiency of the vertical subsurface flow constructed wetlands commonly used for the treatment of domestic and municipal waste water ranges between 31% and 99%.

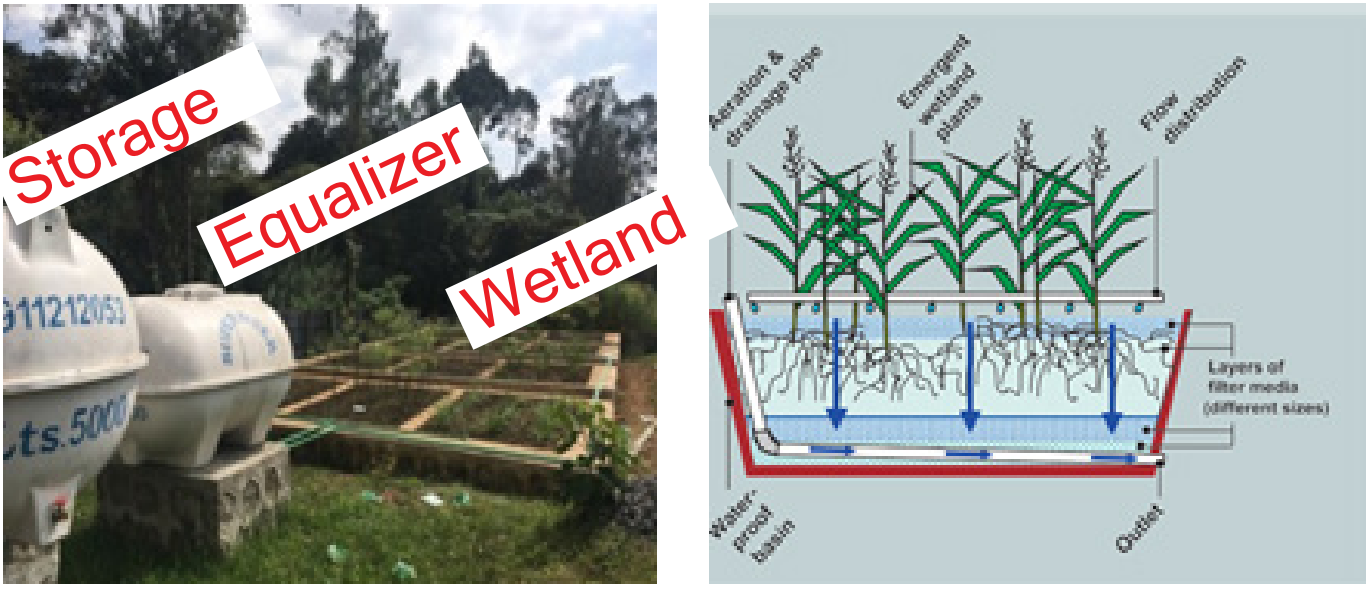

Fig.1 Constructed wetland (CW) site at NFALRC (left) & picture indicating structures in vertical flow CW (right)

Major findings of the study

Table 2. Removal efficiency (%) of wetland plants at different HRT

Parameters*	Treatments											
	Cyperus alternifolius			Cyperus papyrus			Cyperus usitatus			Substrate only		
	Hydraulic Retention Time (HRT)											
3	5	7	3	5	7	3	5	7	3	5	7	
NH4	67.2	71.6	**80.1**	49.2	59.0	**63.5**	46.0	52.7	**61.8**	22.8	28.4	**33.1**
NO3	89.9	93.7	**94.9**	86.6	89.8	**92.8**	88.7	90.4	**88.1**	10.3	14.5	**24.8**
TP	85.6	87.8	**90.2**	86.0	85.1	**91.5**	71.0	82.8	**88.0**	6.5	9.0	**15.5**
TSS	62.0	73.9	**84.1**	59.7	68.5	**81.1**	56.5	63.4	**72.9**	21.6	26.7	**32.5**
BOD5	63.2	70.3	**85.5**	52.0	58.4	**67.0**	44.1	49.5	**67.0**	33.1	36.4	**44.5**
TC	80.1	86.8	**90.1**	76.8	85.5	**87.5**	68.1	73.1	**81.2**	55.0	66.1	**72.8**

Note- *All units are in mgL-1 except for TC which is in CFU mL-1, Figures in bold are highest removal efficiency of treatments.

- Percent removal efficiencies of wetland plants were highest after 7 days of HRT except for Cyperus usitatus where the highest removal efficiency for NO3 was after 5 days (Table 2)
- All the three Cyperus species were found good in treating nutrients, TSS and total coliform bacteria Cyperus alternifolius being the highest.

- Percent removal efficiencies of wetland plants were highest after 7 days of HRT except for Cyperus usitatus where the highest removal efficiency for NO3 was after 5 days (Table 2)
- Substrate only (control) had the lowest removal efficiency for all parameters significantly different ($p<0.05$) between treatments with pants indicating the role of plants in such system.
- Plants used for degradation of organic matter and nutrients (Cheng et al., 2022)
- Establishing an aerobic micro-environment along their roots that favors biofilm development.
- Its extensive root system enhances microbial activity and nutrient uptake (Yuan et al., 2016).
- Wetland plants were not only trap nutrients and suspended solids but also improved the appearance of the polluted water (Fig. 2)
- Further research is required to select multipurpose wetland plants with high waste water removal efficiency, serving as livestock feed and also can be used as aesthetic values (Fig.3).

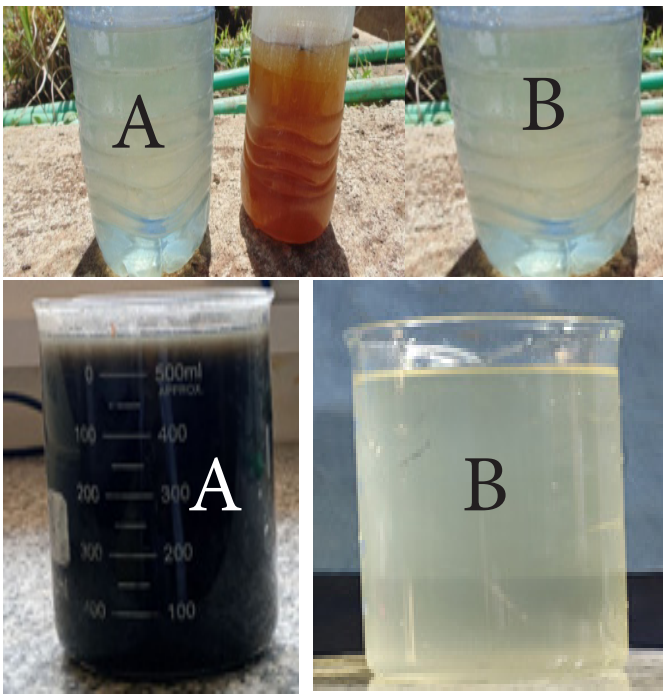

Fig. 2 Wastewater before treatment (A) and after treatment (B)

Fig.3 Wetland plants (grass type left and flowering plants right)

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Ethno-Veterinary Medicine as Livestock Health Medicine: A Promising Technology for Import Substitution of Drugs and Biologicals

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Introduction

Animal Health (Veterinary) research is nationally mandated to undertake different research activities on diseases of trade, zoonotic importance and diseases of production. Accordingly, high priority animal diseases were identified for different levels: nationwide interest, producers' level, market actors, farm households and intensive farming. Due to the presence of emerging, re-emerging, endemic, pandemic, diseases of public health and economic significance, disease outbreaks and mortality of various livestock species, the program is dedicated to technology, knowledge and prototype development, evaluation ,dissemination and promotion, developing manuals and guidelines for the DAs, farmers, Pastoralists, traders, consumers and other users to mitigate livestock mortality and has ten safety of livestock products for the consumers and export opportunities. Currently, the research program is focusing on development, Improvement and evaluation of veterinary pharmaceuticals, complimentary and Ethno-veterinary Medicines.

Ethiopia is home to different medicinal plant species and it was reported that 80-90% of the animal owners uses herbal medicine for the health care of their animals. Ethno-veterinary medicine (EVM) provides valuable alternatives to complement modern veterinary medicine. It is widely used in the developing world to mitigate the prevalence and mortality of livestock species. Animal diseases caused by different pathogens are difficult to treat and

the existing medicaments are either limited or expensive to use or have developed resistance. The biggest risks to human and animal health are the development of antimicrobials, anthelmintics and antiprotozoals resistance, which is increased by continued treatment in certain situations. Additionally, excessive and irrational use of commercial acaricide leads to the widespread emergence of ectoparasiticides resistance tick species and acaricide failures.

Due to the presence of multiple compounds like phenolic elements, steroids, glycosides, cerotic acid and tannins in ethnoveterinary medicines, herbal medicines are alternative therapeutics for different infections, infestations and these certain herbs are serving as backup remedy and can serve as alternative pathogen control medicine. Moreover, traditional ways of treating and preventing animal ailments was practiced by farmers and pastoralists. However, these livestock keeping communities cited lack of documentation, inadequate diagnosis, and lack of knowledge of application rates or side effects of these practices. Moreover, slow rate of production of many medicinal plants, shortage of suitable cultivation technologies, unscientific harvesting, processing and preservation as well as paucity of research on the high yielding medicinal plant and insufficient processing techniques are also the major challenges. On the other hand, the increasing global and national demand for medicinal products accelerated conservation, cultivation, processing, product development and marketing of the bio-products formulated from Ethno-veterinary medicines. Thus, great attention was given to collection, maintenance, multiplication, production, screening, processing and utilization technologies of these endemic ethno-veterinary medicines and practices.

Validation and transferring of this knowledge to users and formulation of alternative drugs from the existing medicinal herbs for promoting, protecting, or restoring the health and well-being of animals well as to further substitute imported commercial drugs, disinfectants and antiseptic biological products is important. These ethno-veterinary medicinal plants can also be used as original sources for pharmaceutical industries, diagnostic laboratories, importers, exporters, farmers, pastoralists and agro-pastoralists, processors and policy makers. Therefore, this pipeline study provides promising results, development and formulation step of alternative therapeutic products from potential ethno-veterinary medicine under different conditions.

A. Development of Promising pipeline products

a) Collection, preservation and processing steps of Ethno-veterinary medicinal plants

The use of herbal remedies by farmers and pastoralists in the treatment of livestock diseases was investigated using a range of methods, including local healers, field visit, observation and demonstration. Different ethno-veterinary medicinal plants registered in Ethiopia were being collected, maintained, preserved and multiplied in the Ethno-veterinary research farms. Research has been undertaking on the identification, screening, characterization, processing and basic understanding of these bio-products for further use in animals.

b) Ethno-veterinary Innovation, formulation and prototype development

EIAR has been serving as technolgy power house by releasing different products, prototypes and practices. The efficiency and efficacy of potential ethno-veterinary medicine for the treatment of ailments and health problems in livestock species as well as development and formulation of products from the identified ethno-veterinary practices have been conducted and verified under in vitro and in vivo assays. Different pipeline products were generated, evaluated and profiled for advancing scientific outputs. Medicinal prototype is an early version of a product from which the next versions are developed or an original material from which new formulation is patterned for use. Prototype generation steps such as pre-formulation before product processing including information related to field use, collection, drying and maceration, and the formulation step includes preparation of standardized dose per dosage inhibitory concentrations, invitro diagnostic efficacy testing on the

cultured and reference isolates and toxicity testing under the in vitro and vivo assays, host and cell responses as well as preparing standardized procedures for the products were undertaken to enhance transfer of outputs.

c) Product verification steps: In vivo efficacy assays on animals, toxicity testing, severity, pathological lesions, host and cell responses.

d) Product release: evaluation, refinement of the procedures due to absence of standard dosage regimen, potential toxicity of certain compounds presents in the medicinal plants and development of guidelines for the pipeline prototypes is needed.

1. **Bio-Efficacy of perisercaria senegalensis:** An in-vitro and in-vivo assays were used to treat clinical ring worm (Trichophyton verrucosum) in infected cattle, and this prototype was found promising to treat fungal skin diseases. The response in treated calves showed healing of the lesion within five days of application

   Product Description: it is a product produced from leaf and seed extract and the mean minimum fungicidal concentration for the leaf component is 6mg/ml and it inhibits the growth of the fungus at 0.78mg/ml.

   Veterinary Prescription: P.senegalensis extract at a concentration of 6mg/ml showed high inhibition of fungal growth at the in-vitro assays. Topical application of the product is practiced on the lesion areas for eight consecutive days and resulted in complete curing rate as compared to commercial drugs.

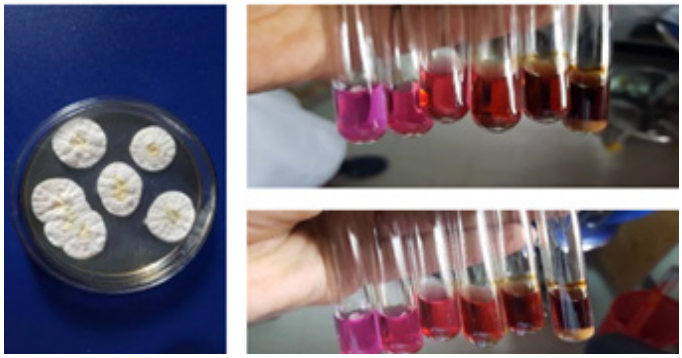

Figure 1: Evaluation step of the product

2. **Bio-efficacy of Ajuga intergrifolia product:** Due to the presence of compounds glycosides, cerotic acid and tannins in Ajuga intergifolia, it serves as backup remedy, to treat bovine mastitis under the farmers context. Mastitic milk serves as a source of zoonotic threats due to spread of diseases and contributes to the development of multidrug resistant pathogens. Alternative herbs such as ajuga integrifolia is important in treating subclinical mastitis.

Product description: Ajuga Intergifolia at different concentration levels (100%, 50%) produced the highest mean of inhibition zone against Staphylococcus aurous and the highest mean of inhibition zone against streptococcus agalactiae which were 5.35± 1.6 and 3.2± 0.4 at 100% and 50% concentrations respectively. Ajuga intergrifolia product is used to inhibit mastitis pathogens and can be used as udder ointments based on the recommendations. An in vivo-bioassays and the standard dosage refinement can be conducted to combat counterfeit products for successful therapy.

Figure 2: Evaluation step of Ajuga intergrifolia product

3. Bio-efficacy of Allover and Curcumba Longa product: In Ethiopia, the availability of the conventional drugs for the treatment of mastitis is limited. Allovera product is an alternative to antibacterial lactaclox for treating mastitis.

- **Product Description:** Allovera and curcumba longa mixture was evaluated under in-vivo and in-vitro techniques to treat mastitis in dairy cow.

- **Veterinary Prescription:** The product is

prescribed as topical application on teat, BID for eight days. More than 60 mastitis sick cows were treated with Allovera product and resulted in complete recovery as compared to commercial drugs.

Figure 3: Application of herbal medicine for treating mastitis

4.Bio-efficacy of calpurnia aurea against cattle ticks: - An in vitro bioassay of calpurnia aurea was conducted to evaluate its potency and efficacy for treating ticks. It has good tick repellent, acaricidal potency and can be used as alternative tick control methods.

- **Product description:** The material was processed, and quantified per gram of extract and in-vitro tick assay was performed. The product was applied by immersion technique and induced tick mortality from 73.3% to 100% at the minimum (6.25mg/ml) and at the maximum dose (200 mg/ml) at 24 hours. The prototype C. aurea can be used as topical tick spray or dip treatment in infested cattle. The leaf extract resulted in 100% mortality at the dose of 100mg/ml with in 6hrs.

Figure 4: Efficacy of Ethnoveterinary medicines agains ticks

5.Thymus vulgaris: was evaluated at the in vitro and in vivo techniques to treat coccidiosis in calves and chicken as alternative product to anticoccidial drugs.

- **Product Description:** a product produced in forms of prophylaxis.
- **Veterinary Prescription:** Thymus prophylaxis is given for diarrheic calves four times per day. 125gram of T. vulgaris powder is mixed with 1kg of concentrate feed and 1/4kg of the mixed concentrate and is given for calves less than one year and 1/2kg for 1 to 2 years old calves to inhibit coccidiosis.

6. Bio-efficacy of N. tabacum M. ferruginea against cattle leech: Leeches are segmented worms with anterior and posterior suckers and get into the mouth when the animals drink infested water. It sucks blood and cause hemorrhage and death due to asphyxia. Unavailability of commercial drug for leech treatment need alternative options such as N. tabacum product.

- **Product Description:** Ethno-veterinary medicine was processed and quantified per gram of extract and the in-vitro-vivo assay was conducted. The extracted product induced leech mortality at the concentrations of 100, 50 and 25 mg/ml respectively.
- **Veterinary Prescription:** The dosage form of the product is prescribed in mg/ml of daily dosage and prescribed as mg/ml for three consecutive days.

Figure 5: Cattle Leech mortality

7. Bio efficacy of moringa stenopetala for treating Eimeria tenella Infected chickens

Moringa stenoptela had antibacterial and antioxidants which enhances the immune system of chicken. Product Description: chickens supplemented with M. stenopetala dry leaf powder increased body weight gain, reduced in oocyst counts, cecal lesions and cecal coccidiosis. The efficacy of product was found better than the action of Amprolium drug and is effective in broiler chicken.

Veterinary Prescription: prescribe 0.75% Moringa stenoptela as daily prophylactic agent in the feed to minimize pathogenesis of cecal coccidiosis and mortality rate.

8. Bio-efficacy of lepidium sativum for treating chicken coccidiosis

- **Product Description:** Lepidium sativum is a medicinal plant, which is termed as versatile medicine. It has protective actions including diuretic, anti-hypersensitive and inhibitory effects than commercial drugs. Hence, the crude extract of Lepidium sativum showed a promising efficacy against sporocysts of different coccidia. A higher In vitro anti-coccidial efficacy extracts of the seed L. sativum was observed at 1000 mg/ml and resulted in reduction of oocyst counts, cecal lesions and mortality, chicken that consumed diet containing the seed powder of L. saticum cured rapidly. The availability and easy administration techniques can initiate producers to use it as alternative coccidiostats.

- **Veterinary Prescription:** Different levels of L. sativum leaves and seed is incorporated in the feed (with 1 g/kg-1 of seed powder, 1 g/kg-1 of whole seed, 1 g/kg-1 of extract) of infected and apparently healthy chicken. Follow the guideline before incorporation and consult veterinarians on the mode of application, dosage and frequency.

9.Bio-efficacy of Neem and Pumpkin Seeds for improving hematological values

maintains greater livability and lower mortality. Biologically active ingredient of this medical plants has different properties. Veterinary Prescription: The serum cholesterol and white blood cell of broilers improved in commercial broiler that fed 1kg of neem and pumpkin seed combination on 100kg of diet(1NS-PS)

Figure 7: Development of alternative products and prototypes

Figure 8: Demonstration of alternative products and prototypes

Figure 9: Formulation of disinfectants and antiseptics

A. Ethno-veterinary Products and pipeline Prototypes

Table 1: Promising Ethno-veterinary disinfectants and Antiseptics

S.No	Alternative and pipeline Ethnoveterinary products/Medicines	Commercial and imported Medicines/ and products
1	P. senegalensis	Lactaclox, Neomycin, Ketoconazole and Oxytetracycline
2	L. Sativum chicken and calf coccidiostats	Amprolium, other antiprotozoal drugs
3	Vernonia amygdalina prototype	Lactaclox, Cloxacillin, Oxytetracycline
4	P. dodecandra prototype	Amitraz 12.5%, Diazinon 60%
5	Aloe vera + curcumba longa	Lactaclox, Cloxacillin, Oxytetracycline
6	N.tebacum M.ferruginea	Ivermectin (1/50) and other drugs
7	C.aurea prototype	Amitraz 12.5%, Diazinon 60%, Ivermectin (ml/50kg)
8	Ajuga Intergrifolia Prototype	Lactaclox, Neomycin, Oxytetracycline
9	Solanica Gigas	Amitraz 12.5%, Diazinon 60%, Ivermectin (ml/50kg)
10	A. Shimperiana coccidiostats	Amprolium, sulphadiazine trimethoprim
11	Milletia laurentii prototype	Amitraz 12.5%
12	Ocimum lamifolium prototype	Diazinon 60%

Table 2: Promising Ethno-veterinary disinfectants and Antiseptics

S.No	**Pipeline Ethnoveterinary disinfectants and Antiseptics**	**Commercial and imported products**
1	P. dodecandra and Amaranthus bio-spray antiseptic and disinfectant)	Savlon containing3% cetrimide and chlorhexidine gluconate 0.3%, Iodine tincture 2% and, and 95% Alcohol
2	Ocimum lamifolium & P. dodecandra (bio-spray antiseptic and disinfectant)	Savlon containing3% cetrimide and chlorhexidine gluconate 0.3%, Iodine tincture 2% and, and 95% Alcohol
3	Ocimum lamifolium bio-disinfectant	Savlon containing3% cetrimide and chlorhexidine gluconate 0.3%, Iodine tincture 2% and, and 95% Alcohol
4	R. amaranthus bio-disinfectant	Savlon containing3% cetrimide and chlorhexidine gluconate 0.3%, Iodine tincture 2% and, and 95% Alcohol

Recommendations

Ethnoveterinary medicine remains an ethnoscientific innovation and reource that is yet to be explored and has a far reaching implication on the economic developmenet and enhacement of veterinary health of particularly rural poor communities ,which donot have access to modern medical services. Therefore,

- There is a need to give research focus on ethno-veterinary medicine and ultimately blending with conventional veterinary practices for import of drug subistitution
- Cultivation of Ethnoveterinary plants and information on the propagation of medicinal plants should be avvailed for the agro-technology industry, Inorder to meet the escalating demands of medicinal plants, establsihing medicinal research farming is important to conserve these plants and use for management of livestock ailments.
- Screening widely utilized ethnoveterinary medicinal plants for their phytochemical constituents, pharmacological properties and toxicity to confirm ethnoveterinary uses and for the development of veterinary pharmaceuticals
- A detailed pharmacological studies on different herbs and ethno-veterinary practices, formulation of potent products and protocols and developing scientific recommendations and standard manuals for users
- Strengthening collaborative research and development networks with different organizations and recommendations should be given to policy makers

Testing and Demonstration of Improved Chicken Strain for Increasing the Livelihood of Farmers

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Holeta Agricultural Research Center of the Ethiopian Institute of Agricultural Research partnered with an International Livestock Research Institute conducted an experiment to test the performance of different chicken strains under small-scale farmers' management in selected intervention districts (Welmera and Berek districts). In each intervention village, each farmer on average 50, obtained a dual-purpose and layers chicken breed. A total of 8400 experimental chickens were delivered to the collaborative and trained farmers with full packages using an innovative business model. Dual-purpose chicken breeds were unsexed while the Bovans brown breed was sexed. In the case of egg production, 50% dual purpose chicken breeds were female, for egg production. At the same time, 100% of Bovan brown was used for egg production. Most farmers (95%) used a commercial diet for layers of chicken in each testing village. The average productive performance of the Bovans brown and female Sasso during the data collection was 91% and 86% respectively.

Table 1: Egg production performance and income generated from layer breed

Village	Average egg produced per day per farmer	Feed cost per produced egg per farmer	Av. daily net income of each farmer	Av. monthly net income of each farmer
Talacho	43	258	215	6450
Gaba Robi	45	258	237	7110
Bakaka	40	258	182	5460
Dabe	44	258	226	6780
Lencha	42	258	204	6120
Girar	43	258	215	6450

Table 2- Income from the sale of male birds at individual farmer and village level

Villages	Total number of male birds sold in each village	Average number of male birds sold per farmer	Total income per village in Birr	Average income per farmer in Birr
Gaba Robi	276	23	331,200	27600
Talacho	250	22	300,000	26,400
Bakaka	225	19	270,000	22,800
Dabe	252	21	277,200	23100
Lencha	276	23	303,600	25,300
Girar	228	19	250,800	20900
Total	1507	127	1,732,000	146,100

Conclusion

On-farm chicken performance testing (OCPT) can significantly improve the livelihoods of small-scale farmers by providing valuable insights that lead to better management practices, increased productivity, and profitability. So, testing different chicken strains in specific agro-ecological contexts is a strategic approach that enables farmers to optimize their poultry operations. By understanding which strains perform best under local conditions, farmers can enhance productivity, improve resource efficiency, and adapt to environmental challenges. This results in better economic outcomes and contributes to the sustainability and resilience of agro-ecosystems, benefiting both farmers and their communities.

Linking Small-scale Poultry Farmers with the Inputs and Output Markets: A Case of Tropical Poultry Genetic Solution (TPGS) Project Activities at Holeta Agricultural Research Center

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Introduction

The Ethiopian Institute of Agricultural Research has been conducting many poultry research activities for the development of the poultry sector. This work has made enormous improvements to social livelihood and the national economy at large. Considering the ever-increasing demand for poultry products, poultry research for development was recently started and inaugurated as a process at Holeta Agricultural Research Center by the Ethiopian Institute of Agricultural Research. As a strategic approach, a sustainable and inclusive partnership is our priority area in advancing poultry research for development activities. Based on this fact EIAR established the collaborative research agreement with the International Livestock Research Institute on tropical poultry genetic solutions project as the SAPLINGnitiative of CGIAR. The aims of this research process are: to introduce, evaluate, demonstrate, and scale up poultry technologies and best practices that can address the nutritional and economic demands of the local communities. The aims of this research process are: to introduce, evaluate, demonstrate, and scale up poultry technologies and best practices that can address the nutritional and economic demands of the local communities.

Research showed that little information was generated on how smallholder farmers outside value chains were addressed and less commercially-oriented farmers access financial services of any kind, or the types of products and services they demand. At the same time, there is recognition of a missing in Agricultural finance in that there is limited understanding of what happens outside the commercial and or model farmers and a tight value chain segment when it comes to serving in financing model farmers.

In line with the above-mentioned strategic priorities, local partners and actors were identified to implement practical technologies in the planned

Fig. Farmers agreed to save in a bank

time frame. Technological products and or input suppliers (feed, medical inputs, and equipment) in collaboration with agricultural development offices of the Berek and Welmera districts were explored and informed to serve field evaluation and demonstration. The training was given to farmers and input suppliers to make a common understanding. Then a lot of farmers benefited from the linkage node and promising results and experiences were also delivered to nearby farmers

Challenge mitigation systems
The main emerging problems and mitigation strategies during this research activity were:

a) Raising chicken feed prices and using local products as an alternative solution

The prices of feed have risen due to the rise of the imported ingredients for the commercial ration formulation but the profitability of the farmers from live chicken and eggs price was down. This factor makes the business of poultry production unprofitable and raises the concerns of any actors in poultry production. Then the option has been set as a short and long plan to solve the enquiry of the farmers on the price of the chicken feed. Engaging private actors who can provide quality chicken feed at a lower cost to the farmers is the first option. Yegna Farms which is based at Bishoftu /Addis Ababa is interested in working with targeted farmers in two testing sites and started to establish a feed mill processing machine to process feed from local products at Holeta and Sendafa to address the balanced feed to the area.

b) Inputs and output market
Linking small-scale farmers to markets is essential for enhancing their economic viability and sustainability. Effective strategies include strengthening farmer organizations, promoting sustainable production methods, and providing access to business services. This integration enables farmers to better access markets, negotiate fair prices, and improve their overall productivity and income. Linking smallholder farmers to markets offers numerous benefits, which can significantly improve their livelihoods and the agricultural sector as a whole. Generally, access to financial institutions for loans and savings services is a fundamental component of enabling small-scale farmers to thrive. By providing the necessary resources and education, these institutions can significantly enhance theeconomic well-being and resilience of farming communities.

Access to loans is essential for small-scale farmers to expand their operations and procure necessary inputs. Efforts have been made to connect farmers from the Welmera and Berek districts with supportive banks such as Sinqe, Oromia Cooperative, Awash, and Enat Bank. Farmers have begun opening accounts at Sinqe Bank, committing to save 2000 birr monthly from their egg income. This initiative aims to help them secure loans and services for farm expansion. Additionally, ongoing discussions with other banks focus on developing more attractive and profitable financial packages tailored for small-scale poultry farmers.

Conclusion

Establishing a sustainable input and output mar ket linkage with small-scale poultry farmers is a crucial component of the TPGS project research efforts, as it is essential to the poultry production modernization and profitability. Therefore, given the current state of affairs, we must expand on these efforts and scale up the most effective business plan for all farmers. Therefore, it is possible to develop a successful and sustainable
business model for small-scale chicken farmers by emphasizing quality, local participation, and diverse revenue streams.

Why Mothering Units in Poultry Production? A Case of Tropical Poultry Genetic Solutions Project Activities in Oromia, Ethiopia

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Background

Tropical Poultry genetic solutions of the International Livestock Research Institute and Ethiopian Institute of Agricultural Research initiated an innovative approach called mothering units which is used to deliver chicken to nearby villages and linking them with small-scale farmers to address unresponsive demands. This approach has great opportunities for the sustainability of poultry production in a well-managed system. Establishing mothering units plays a pivotal role in the modernization of the poultry production sector and also serves as a domain chicken delivering units for the local communities at large. There are key criteria that are needed to establish a mothering unit to co-create a sustainable poultry production system under small-scale farmers in developing countries.

Key indicators of productive performance at mothering unit

a) Feed intake and Body weight

Feed intake and body weights are critical factors in poultry production for affecting the health, production efficiency, and profitability of poultry operations. The mean feed intake of chickens can vary depending on factors such as their age, breed, purpose (broilers vs. layers), and environmental conditions. The body weight of chickens varies significantly depending on the breed, age, and purpose (for meat production or egg-laying). Monitoring and managing body weight is essential for optimizing economic returns and maintaining the health and welfare of chickens in production systems. Given its multifactorial importance, understanding the implications of body weight can lead to more sustainable and profitable poultry production.

Table 1: Feed intake and Body weight during a mothering unit

Age in weeks	Feed intake(gm)		Average Body weight(gm)	
	Sasso	Bovans brown	Sasso	Bovans brown
1	13	11	76	59.5
2	21	17	185	118.5
3	28	24	238	172.3
4	33	31	415	242.12
5	39	36	436	337.00
6	43	41	478	450.00

Conclusion

The establishment of a well-organized mothering unit has led to significant improvements in key productive performance parameters that are essential for successful poultry management. This well-structured approach has effectively contributed to a notable reduction in the mortality rates of chickens, thereby enhancing overall flock health and productivity.

Advancing Agricultural Mechanization for Sustainable Production and Food Security Capacity Development in Ethiopia

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Introduction

Agricultural mechanization, which involves the use of farm power and different implements in farming activities, plays a key role in enhancing agricultural productivity and ensuring food security (Daum & Birner, 2020). The integration of these tools with relevant farm power units not only increases production but also contributes to poverty alleviation in two significant ways: by improving the timeliness of operations and ensuring good quality work. In farm tasks such as cultivation, seedbed preparation, crop protection, and harvesting, where human and animal power may be insufficient, the need for adequate power and proper implements becomes paramount. Recognizing the importance of agricultural mechanization and related initiatives, the Ethiopian Institute of Agricultural Research (EIAR) incorporated the former Ethio-German Agricultural Training Center currently renamed as Kulumsa Agricultural Mechanization Research and Training Center (KAMRTC) into its organizational structure in January 2021. Taking this into account, this report aims to assess the significance of trained farm machinery and implement operators and technicians in sustaining agricultural production and productivity. It emphasizes the critical importance of proper operation, hitching, adjustment, and maintenance, highlighting the pivotal role of KAMRTC in promoting agricultural mechanization in Ethiopia.

Agricultural machinery has significantly increased production and productivity on a global scale. For instance, in the United States of America, at the end of the 19th century, it took 35 to 40 hours of planting and harvesting labor to produce 3,520 pounds of corn. However, thanks to mechanization, a hundred years later, the same amount of corn could be produced in just 2 hours and 45 minutes (Smith, 2024). This advancement has enabled farmers to complete farm operations such as land preparation, planting, harvesting, threshing, and irrigation application faster and more efficiently. Moreover, mechanization reduces drudgery, thereby encouraging farmers to engage in various farm operations. Modern machinery incorporates advanced technologies such as global positioning system (GPS) guidance systems and sensors, which enable precise application of inputs such as fertilizers, pesticides, and irrigation water, leading to resource optimization (Smith, 2024). Furthermore, the deployment of machinery in smart farming, including conservation agriculture technologies (CA), helps to mitigate climate change challenges in crop production (Javaid et al., 2022).

The availability and efficient use of farm power are crucial for sustainable crop production. Reliable machinery and appropriate tools are essential for various farm operations. Ethiopia has made notable strides in mechanization over the last few years, particularly in Oromia regional state. The increase of farm machinery, farm machinery service providers, irrigation pumps, cluster farming, and farmers' cooperative unions owning machinery reflects this progress. However, there is still a need to expand machinery utilization beyond primary and secondary tillage operations and to enhance capacity building at both technical and managerial levels.

Generally, agricultural mechanization holds immense potential for enhancing farm productivity and food security in Ethiopia. Establishing capacity-building centers like KAMRTC signifies a commitment to advancing mechanization efforts. To fully harness the benefits, there is a necessity for continued investment in infrastructure, training, and technology adoption across the agricultural sector. To pave the way for a more resilient and productive agricultural sector in

Ethiopia, the progress in mechanization must be coupled with sustainable infrastructure and skill development efforts.

Maximizing Agricultural Productivity through Farm Machinery Operators and Agro Mechanics Training

Effective operation and maintenance of agricultural machinery are essential for enhancing productivity and efficiency in farming. This article emphasizes the significance of adequate training and regular maintenance in optimizing machinery performance and minimizing downtime, ultimately leading to increased agricultural output and reduced production costs.

Standard operation and maintenance of agricultural machinery are essential for maximizing productivity across various agricultural activities. Adequate training ensures that operators possess the skill needed to operate machinery efficiently and safely. Regular maintenance prevents unexpected breakdowns, reduces downtime, and minimizes the likelihood of costly repairs. Furthermore, well-maintained machinery improves efficiency in tasks that require narrow windows of operation such as planting, harvesting, irrigation, and pest control, resulting in increased output per unit of time and labor.

Preventive maintenance prolongs machinery lifespan, reduces wear and tear, and minimizes replacement costs. Additionally, timely maintained machinery performs more safely, reducing the risk of accidents for operators and bystanders. Besides, efficient machinery operation leads to optimal resource utilization, including fuel and lubricants, further contributing to cost savings and sustainability.

Therefore, desired operation and maintenance of agricultural machinery are fundamental in improving agricultural productivity and sustainability. This indicates, investing in training programs for operators and mechanics, along with regular maintenance schedules, is essential for maximizing the potential of agricultural machinery and ensuring food security for communities worldwide.

Integration of KAMTC to EIAR

The integration of the KAMRTC into the EIAR stems from a series of strategic developments and achievements since its inception in 2009. The idea machinery operators emerged in 2009, culminating in an agreement between the Governments of Germany and Ethiopia in 2010. Subsequently, the "Ethio-German Further Agricultural Training Centre" project was launched in 2011 at Kulumsa Agricultural Research Centre (KARC). Over time, it evolved into the Agricultural Training Centre for Mechanization (ATC) and became an integral part of the "Supporting Sustainable Agricultural Productivity in Ethiopia" (SSAP) program, which was financed by the German Federal Ministry of Food and Agriculture (BMEL) on behalf of the Government of Germany and implemented through giz.

Under the umbrella of ATC, numerous activities were undertaken to promote mechanization in Ethiopia. From February 2011, a total of 7,159 participants (6,380 male and 779 female) received training and demonstrations on farm machinery selection, management, maintenance, operation, hitching, and adjustment, accumulating 21,315 man-days. Modern agricultural practices were demonstrated with improved conventional and conservation farming implements like stubble mulching, improved reversible moldboard plough, combined seed drill, tractor mounted chemical applicator, lime applicator, etc at KARC. As a result of these improved farming practices, yields in demonstration plots of KARC increased by 52%, (ATC Report, 2017), the number of farm machinery service providers in Arsi zone increased, and the deployment of modern machinery expanded in Arsi, with potential scalability to other areas.

ATC earned accreditation from the Oromia Occupational Competence Agency (OOCAA) and the Federal Transport Authority (FTA) to be a center of assessment for farm machinery operations from Level I–IV and a training center for farm machinery and equipment operation, including tractor and combine harvester, respectively in 2019. This recognition addressed challenges faced by investors, machinery service providers, farmers' cooperative unions, and commercial farm owners

in sustaining crop production due to cooperative unions, and commercial farm owners in sustaining crop production due to a lack of qualified machinery operators. The first batch of tractor operators assessed by OOCAA on March 26, 2020, showed a competency rate of 93.75% (ATC Report, 2020).

Recognizing the potential of mechanized agriculture in Ethiopia, H. E. Mr. Oumar Husien, the ex-Minister, Ministry of Agriculture, decided to integrate ATC into the structure of EIAR in February 2020. This decision aimed to ensure the sustainability of ATC's efforts in promoting agricultural mechanization. Following the minister's decision, a committee comprising three members from EIAR and one member from GIZ/SSAP was formed by the then-Director General of EIAR, Dr. Mandefro Nigussie, to study the legal requirements and identify the appropriate directorate for ATC's integration. After careful consideration of mandates, manpower requirements, and legal issues, ATC was integrated into the Agricultural Engineering Research Directorate, with an expanded mandate to conduct research in the field of farm machinery. Consequently, ATC was renamed the "Kulumsa Agricultural Mechanization Research and Training Center."

The integration of KAMRTC into EIAR ensures the sustainability of the institution and enhances its capacity to drive research and training initiatives in agricultural mechanization. This, in turn, contributes to the country's agricultural development goals.



Enhancing Agricultural Productivity: The Impact of KAMRTC in Ethiopia

The KAMRTC has been a seminal force in the enhancement of agricultural output and efficiency in Ethiopia, facilitating the uptake of agricultural machinery and equipping stakeholders with the requisite skills, knowledge and attitudes. The KAMRTC has achieved its goals through a multifaceted approach encompassing training, research, extension activities, and strategic partnerships. These initiatives have contributed to the promotion of mechanized farming methods and the empowerment of stakeholders with essential skills and knowledge, thereby facilitating sustainable agricultural development. In the course of seven intensive training sessions, KAMRTC has provided accredited programs to a total of 253 professionals, with a particular focus on the standard operation, maintenance, and repair of agricultural machinery. Furthermore, 590 individuals, comprising machinery service providers, youth groups, members of Farmers Cooperative Unions (FCU), and development agents, have received training to enhance their skills in the areas of farm machinery selection, management, and handling. This comprehensive training program provides operators and professionals with the requisite expertise to utilize machinery effectively, thereby enhancing productivity in the agricultural sector. KAMRTC serves as a hub for disseminating modern agricultural technologies and demonstrating the benefits of mechanization to farmers. Through dynamic demonstrations of the latest equipment and practical examples in demonstration plots, farmers gain insights into the impact of agricultural machinery on crop yields, efficiency, and profitability. Furthermore, KAMRTC facilitates access to machinery and equipment through cooperative arrangements, especially for smallholder farmers, enabling broader adoption of mechanized farming practices.

Concurrently, KAMRTC engages in research activities aimed at improving agricultural machinery and adapting it to local farming conditions.

Research efforts focus on identifying appropriate machinery for different crops and farming systems, as well as to develop innovations that will enhance efficiency and performance of the equipment. These endeavors contribute to advancement of mechanization in Ethiopian agriculture while simultaneously addressing the specific needs of smallholder farmers.

In addition to training and research, KAMRTC offers extension services to farmers, providing technical assistance, troubleshooting support, and advisory services related to agricultural machinery. The center places significant emphasis on the promotion of sustainable mechanization practices, with a particular focus on the advancement of conservation tillage, precision agriculture, and resource-efficient farming methodologies. This approach ensures that the environmental impact is kept to a minimum while simultaneously enhancing productivity.

KAMRTC has spearheaded the introduction and demonstration of various advanced agricultural machinery and equipment in Ethiopia. These innovations include lime spreading machines, stubble cultivator and incorporators, direct planters for conservation agriculture, modern soil tillage implements, planters for different crops, pesticide applicators, and specialized harvesting tools for different crops including tef harvesting, mechanical weeding tools, urea top dressers, pulse threshers, and potato planters, moulders and harvester. Notably, the introduction of specialized tools for tef harvesting addresses a longstanding challenge faced by farmers using conventional methods.

Since its inception as a project in 2011, KAMRTC has conducted seven comprehensive training programs and several skill upgrading training courses, equipping over 8,402 trainees with essential skills, knowledge and attitude in the operation, maintenance, management, and handling of agricultural machinery. The trained professionals play a vital role in mechanized agricultural activities, ensuring the efficient operation and maintenance of agricultural machinery and providing troubleshooting support when required.

Notably, KAMRTC has collaborated with the Ethiopian Army Foundation of the Ethiopian Defense Force, providing specialized training to operators and mechanics. In this specialized training 50 farm machinery operators, and 28 technicians were certified to operate and carryout maintenance of farm machinery. Besides, KAMRTC has supported the army foundation in establishing and developing about 100 hectares of farmland for soya bean and mung bean production in Derashe, South Ethiopia and 900 hectares for bread wheat production in Meki, Oromia regional state. This partnership enables professionals to effectively operate and maintain the army foundation's agricultural machinery for large-scale farming operations. The collaboration supports the army foundation's strategic objectives, including achieving food self-sufficiency for all members of the Ethiopian defense forces, combating inflation, and ultimately contributing to import substitution and the export of value-added agricultural commodities.

In conclusion, KAMRTC plays a pivotal role in enhancing agricultural productivity through its comprehensive approach to promoting mechanization and the effective utilization of agricultural machinery. By providing training, disseminating technology, conducting research, and providing extension services, the center makes a significant contribution to the prosperity and resilience of farming communities, by empowering stakeholders. Through the introduction of innovative machinery, comprehensive training programs, and strategic partnerships, KAMRTC plays a crucial role in modernizing Ethiopian agriculture and enhancing productivity across the sector. The initiatives undertaken by KAMRTC exemplify its dedication to advancing agricultural mechanization and training, which ultimately contribute to the sustainable development of agriculture and food security in Ethiopia.

Conclusion

In conclusion, the effective operation and maintenance of agricultural machinery are vital for enhancing productivity, efficiency, and sustainability in farming. By prioritizing adequate training and regular maintenance, farmers can optimize machinery performance, reduce downtime, and ultimately increase agricultural output while minimizing costs. The KAMRTC integrated into broader agricultural frameworks such as the Ethiopian Institute of Agricultural plays a major role in driving research, training, and innovation in agricultural mechanization.

The multifaceted approach of KAMARTC encompassing training, research, extension services, and strategic partnerships, KAMRTC facilitates the broader adoption of mechanized farming practices, contributing to national objectives such as food security and import substitution. As Ethiopia progresses towards modernizing its agriculture sector, the commitment to sustainable agricultural development embodied by institutions like KAMRTC ensures a prosperous future for Ethiopian agriculture.

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Sorghum Technology Outreach

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Introduction

Sorghum (Sorghum bicolor (L.) Moench) is one of the most widely grown cereal crops in Ethiopia. It has tremendous uses for the Ethiopian farmer, and no part of this plant is ignored. The sorghum crop grows in a wide range of agro-ecologies, most importantly in the moisture-stressed parts where other crops can least survive and food insecurity is rampant. Mieso district of West Hararghe is among the drought-affected areas where drought-resistant sorghum is very crucial.

The farmers of the Mieso district said that they are hoping to get a good harvest from the improved seeds they planted last winter. (OBN Cyber Media' 2024). Chiro National Sorghum Research and Training Center Director, Mr. Temesgen Teressa, said that sorghum varieties that produce good yield have been identified through research and are being distributed to the farmers.

According to the Coordinator of the National Sorghum Research Program, Mr. Tokuma Legesse, 63 improved sorghum varieties have been delivered to the farmers so far.

Figure 1. Participation of stakeholders during demonstration

At the national level, EIAR is responsible for contributing to the transformation of Ethiopian agriculture through three strategic pillars of technology generation: initial and source technology supply, demand creation and distribution of better agricultural technologies and information.

The Agricultural Extension research program is responsible for disseminating technology and knowledge, increasing associated capacity, strengthening linkages and partnerships, and handling feedback from technology adopters and beneficiaries.

Technology promotion and seed multiplication

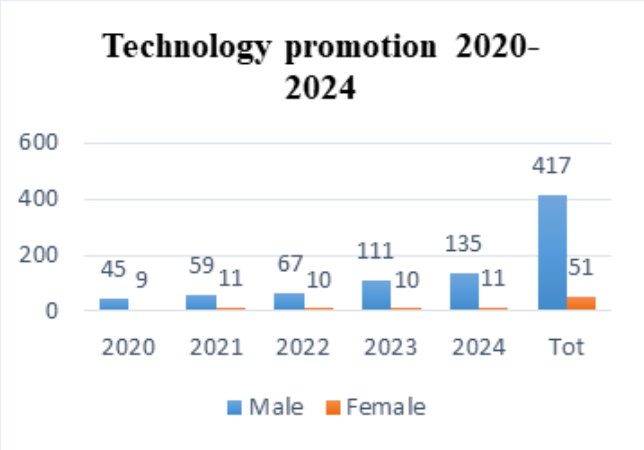

Figure 2.Technology Promotion 2020-2024

One of the effective ways to boost productivity at the farm level is by introducing and promoting improved agricultural technologies to farmers. Therefore, at Mieso and Gumbi Bordode districts, a total of 28 large-scale demonstration plots of improved sorghum varieties have been conducted in 2014–2024.

Finally, each farmer harvested an average of 10qt of sorghum from their lands, which was a double advantage after Mung bean has been harvested. Farmers also feel happy and they also show tendency to produce sorghum for the coming season as double cropping after bean.

The Melkam demonstrations, has shown great potential to increase productivity among smallholder farmers. Numerous studies indicate that large-scale demonstrations of different crop varieties significantly raise awareness and adoption rates of improved varieties.

Figure 3. Community based seed Multiplication of Melkam Variety

A community-based seed multiplication scheme has empowered farmers at Mieso districts to produce quality seeds. This approach does not only improve seed availability but also supports sustainable agricultural practices in the district.

Implication

In the Mieso district popularization of Melkam Sorghum variety is essential for increasing its coverage by promoting the practical application of scientific knowledge and improving land management practices. It serves as a bridge between research and real implementation.

Agricultural efficiency and behavioural change

Farmers can now use cropland more efficiently by using double cropping strategy. The land coverage of the Melkam sorghum variety is increasing from year to year. Practices such as row planting, effective crop management, and water conservation have been successfully demonstrated. As a result, positive behavioural changes have occurred in the district, leading to better utilization of crop varieties and advancements in conservation agriculture. In 2024, more than 450 hectares of land were covered by the Melkam Sorghum variety in the district. It has been distributed in several media and also shared by different social Medias.

Figure 4. Large scale demonstration was broadcasted to local Medias (OBN and ETV)

Advantages of Melkam sorghum variety

In addition to high yielding, the Melkam sorghum variety provides several merits, food, feed, fodder, and also early maturing that support double cropping with Mung bean, especially in regions with challenging climatic conditions and are known as bimodal rainfall like Mieso. Its early maturity and adaptability enable farmers to grow it in succession with other crops, optimizing land use and enhancing food security. Hundreds of farmers in the Mieso district have successfully used Melkam and Mung bean for double cropping, providing significant benefits to their households.

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