Post Conference Report

The 2nd African Conference on Precision Agriculture

Ethiopian Institute of Agricultural Research,

Natural Resource Management Research Directorate

Satellite site: Ethiopia

Venue: Adama, Rift valley hotel

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HOSTED BY

ORGANIZED BY

Introduction

The 2nd African Conference on Precision Agriculture (AfCPA) held its main conference between December 7 – 9/ 2022 in Nairobi, Kenya, along with a network of in-person satellite conference sites located across Africa, including Ethiopia, all connected through a virtual conference environment. In Ethiopia, the conference was held at Rift Valley Hotel, Adama. A total of 20 professionals from Ethiopian Institute of Agricultural Research, Ministry of Agriculture, CIMMYT, Addis Ababa University, Araba-minch University, Jimma University, and South Agricultural Institute participated.

The mission of the AfCPA is to "connect the science and practice needed to put precision agriculture in action for Africa." Through this mission, AfCPA seeks to provide a pan-African platform focused on highlighting new advances in the fields of experimental and applied precision agriculture. Thus, the conference was found to be very helpful to engage key stakeholders including soil scientists, extension staff, modelers, advisors, agronomists, and service providers towards the common goal of building the capacity and resilience of African cropping systems. In line with this, the conference held at Adama helped to bring together professionals from different disciplines and contribute to the promotion and advancement of PA in Ethiopia. The topics of oral presentations included: effects of climate change on rain-fed agriculture, digital agriculture technologies as enabler for climate smart farming in Ethiopia, application of UAV technologies for disease forecasting and wheat breeding data collection, the role of national agricultural datahub towards precision agriculture, modeling and mapping for site specific lime recommendation, developing tailored and location-specific digital agroadvisory decision support tool in Ethiopia, efficiency of lime and phosphorus use, and cropping systems. In conclusion, the conference was successful and the coordinators of the conference appreciate the contribution of all invited guests and presenters.

Session one (Day 1, mooring)

On the first day, Dr. Dawit Abate welcomed the participants and invited Dr. Tolesa Debele, Ethiopian Institute of Agricultural Research (EIAR) to officially open the conference and make a keynote speech. Accordingly, Dr. Tolesa made an interesting keynote speech, mentioning how precision agriculture (PA) evolved and the need to implement PA practices in Ethiopia. Then, Mr. Tadesse Anberbir introduced the conference format and the three day's program.

The conference was held for 3 days, with the morning session entirely left for virtual conference and afternoon session for local presentations and discussions. All morning session programs were attended by all participants; but, there was no interactions on issues raised from the main host center. Thus, this report did not include the contents of the presentations in the virtual conference. The following sections focused on the local presentations, discussions, and conference uptake.

Presentation 1: Effects of Climate Change on rain-fed agriculture and evaluating the irrigation potential to enhance crop production, a case of Hare Watershed, Ethiopia.

By Manyazwal Getachew

The presentation focused on investigation of surface water resources for the potential use of irrigation and the impacts of climate change on rain-fed agriculture in Hare watershed, Ethiopia. Projected climate variables were used in two scenarios (RCP 2.6 and 4.5) which were used for

future climatic conditions of the two future periods; near term (2015 – 2044) and mid-term (2045–2074). Sen's estimator and Mann-Kendall's statistical tests were used for trend detection using XLSTAT. HEC-HMS is used for the volume of available water content estimations and the CROPWAT model is used to estimate crop and irrigation water requirements.

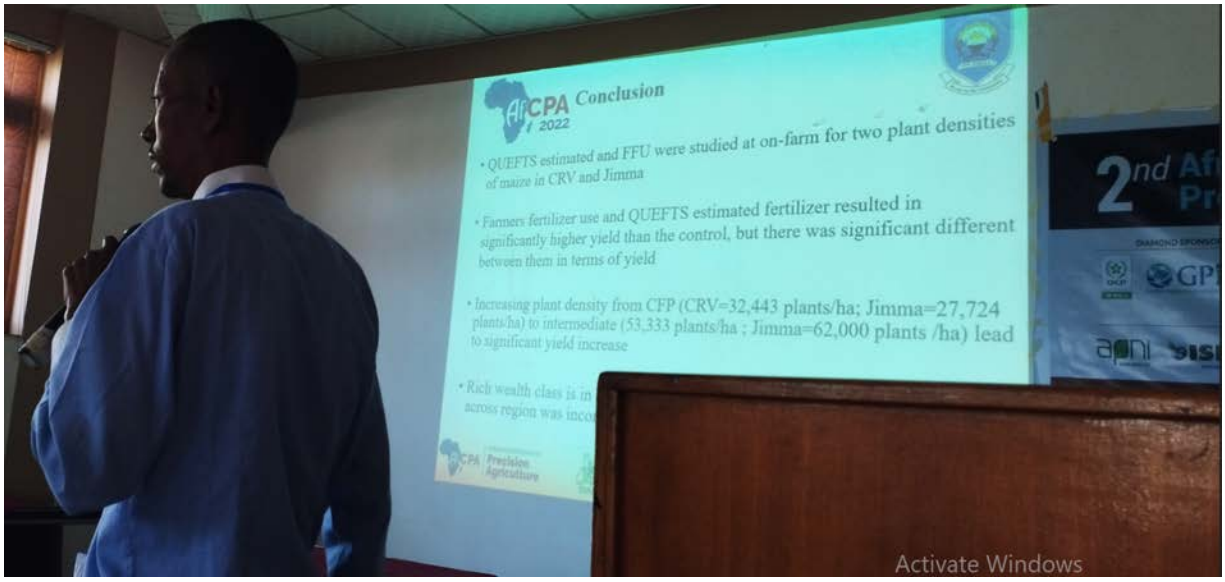
The impact of climate change on the available water content of Hare River watershed show that runoff depth expected to decline by 3% for both scenarios, in the period of 2015 to 2044, and again by 2% and 5% for RCP 2.6 and RCP 4.5 scenarios, respectively in the period 2045 to 2074. Generally, the volume of available water content of Hare River watershed is expected to decrease in the future. Therefore, there is a need for adequate provision of irrigation and drainage infrastructures, which is critical for climate change adaptation.

Presentation 2: Precision maize nutrition: evidences from on-farm experimentation of QUEFTS estimated nutrient requirement for variable densities in smallholder farmers in Ethiopia.

By Workneh Bekere

Workineh presented on the use of QUEFTS (QUantitative Evaluation of the Fertility of Tropical Soils) model for estimating optimal nutrient requirement of crops. QUEFTS estimated (QE) nutrient requirement of maize in two plant densities (32,443 and 53,333 plants/ha in Central Rift Valley (CRV) were compared with the fertilizer rates being used by farmers. Comparisons were made based on yields obtained. Model estimated for two plant densities: 27724 and 62,000 plants/ha in Jimma on farmers' fields of 3 wealth classes (poor, medium and wealthy) in contrasting agro-ecologies of Ethiopia. QUEFTS estimated 40.8, 0.0 and 12.2 kg/ha N, P and K in CRV (50% of water limited potential yield (Yw) =3.1 t/ha) whereas in Jimma (50% of Yw=7.5 t/ha) 149.8, 9, 130.6 kg/ha N, P and K were estimated for the production of 50% of Yw. For production of 70% of Ym in Jimma, 211.5, 26 and 141 kg/ha N, P and K were also estimated by the model. The yield from the model estimated nutrients were compared with the control and the fertilizer rates being used by farmers in the two regions for two plant densities. In 2018, plant density and wealth class did not affect maize yield in CRV. However, in 2017, fertilizer use, plant density and wealth class had a significant effect on maize yield in both CRV and Jimma. QUEFTS predicted nutrients resulted in higher yield, but the yield advantage is not significantly higher

compared to farmers' fertilizer uses in both regions. Increasing plant density from current to 53,333 plants/ha in CRV and to 62,000 plants/ha in Jimma led to more yield improvement than improving fertilizer recommendations.



Presentation 3: Effects of Legume Break Crops on Yield, Nitrogen Use efficiency and Economy of Maize Production in Western Oromia, Ethiopia: A Review.

By Tolera Abera (PhD)

According to the author, the use of legume break crops in maize producing areas improved performance of subsequent maize. The biological N_2-fixation of legumes as precursor crops reduced the amount of nitrogen fertilizer applied to maize. Higher mean grain yield of maize was obtained following faba bean and soybean without and with rhizobia inoculation than maize after maize. The total nitrogen uptake of different maize varieties was improved following leguminous break crops with application of lower amounts of nitrogen fertilizer. Higher agronomic nitrogen efficiency, fertilizer N recovery efficiency and nitrogen use efficiency of maize were obtained from 55 kg N ha^{-1} following legume break crops, as compared to 110 kg N ha^{-1} under monocropping of maize. Thus, 55 kg N ha^{-1}, following faba bean or soybean, is recommended for production of both highland and mid altitude maize varieties in western Ethiopia.

Presentation 4: Modelling and Mapping for Site Specific Lime Requirement Estimation for Acid Soils Management in the Highlands of Arsi Zone, Oromia Region, Ethiopia.

By Dawit Habte (PhD)

The author presented his work on model development and mapping for variable rate or spatially explicit lime requirement estimation for acid soils of Arsi zone, Oromia Region, Ethiopia. Lime requirement prediction models were developed using data generated through direct titration of soils with $Ca(OH)_2$ and validated using 2 years field experiment data. The study revealed that pHw was found to be a better predictor variable than CEC for modeling LRs. The pHw and $Ca(OH)_2$

data sets fitted to Mitscherlich's model, with R^2= 0.97-0.99. Soil pHw and grain yield (GY) of bread wheat were highly correlated with Pearson's correlation coefficient: r= 0.97-0.99. The lime levels that brought soil pHw to near asymptotic maximum and relative GY above 95% were between 1800 – 2400 kg $Ca(OH)_2$/ha. Finally, LR maps were generated using lime requirement model and 165 georeferenced pHw data. In conclusion, LR models and surface maps generated using geostatistical methods can be applied for precision management of acid soils.

Presentation 5: Lime and Phosphorus Effects on Soil Acidity and Malt Barley Phosphorus use Efficiency in Welmera District, Central Highlands of Ethiopia.

By Geremew T Negeri (PhD)

The presentation is about liming and phosphorus (P) to improve availability and fertilizer use efficiency of P on acid soils. Application of appropriate rate of lime and P fertilizer is an important strategy for improving crop growth in acidic soils. The experiment was undertaken at Welmera district Oromia Region to determine the effect of lime and P on soil pH and P use efficiency in 2018. Acidic fields that have not been previously reclaimed with lime since last 5 years were selected, Six rate of lime (0, 1.56, 2.34, 3.12, 3.9 and 4.68 t ha^{-1}) and 3 rates of P (0, 16.5 and 33 kg ha^{-1}) arranged in factorial randomized block design in 3 replications. Soil pH increased and exchangeable acidity reduced after amending the soil with lime. Lime and P fertilizer greatly contributed for improvement of soil chemical acidity and P use efficiency. In conclusion, application of 3.12 t lime ha^{-1} with 16.5 kg P ha^{-1} fertilizer is recommended for study area.

Figure 1: picture showing participants in the afternoon and morning sessions of Day 1

Poster presentations

1. Evaluating Nitrogen use Efficiency and Crop Performance through Application of Urea Stabil under Balanced Fertilizer for Tef on Vertisol, in central highlands of Ethiopia, Girma Chala
2. Mapping the Spatial Variability, Status and Magnitude of Soil Acidity in Semen Ari district of South Omo, Southwestern Ethiopia, Abebe Hegano
3. Analysis of flood events in Dire Dawa, Ethiopia using WRF-Hydro, Yonas Mersha

4. Deep Learning Weather Prediction on Seasonal Precipitation Forecasting for Ethiopia, Kaleab Yared
5. Effect of integrated use of lime and vermicompost on faba bean productivity and selected chemical properties of the soil in acid prone areas of Ethiopia, Derib Kifle Belda

Figure 2: picture taken during poster presentations on day 2

Session two (Day 2)

Presentation 1: Digital agriculture technologies as enabler for Climate Smart farming in Ethiopia,

Dr. Kinde Fantaye

Dr Kinde discussed different issues: technologies that can help drive PA for small scale farmers are discussed. Examples are use of SMS, USSD, IVR to transfer information on farm specific issues. Climate effects on agriculture as critical issues to address are discussed. The challenges to technology transfer are highlighted: limited knowledge, lack of awareness, literacy, and shortage or lack of power supply.

The importance of satellite images and their analysis to scale up PA is discussed. The challenges of satellite image analysis and use are: spatial and temporal resolution, analytical challenges, and the challenge posed by mixed farming for image processing.

The importance of UAV for precision agriculture was also discussed. Real time imaging, spraying, and scouting are highlighted. The challenges of UAV for advancing PA are also highlighted: battery life, line of sight, regulation for the use of drones, technological and analytical capacity are well discussed. The other important technologies that can be applicable to advancing PA are internet sources, variable rate technologies (VRT), and decision support systems, like DSSAT.

The most important part of the presentation (Digital agriculture technologies as enabler for Climate Smart farming in Ethiopia) is digital agro-advisory required based on weather forecast information. According to the presenter, the organization is reaching about 60000 customers. The services are expanded to include crop yield prediction using CCAFS and CRAFT (Regional Agricultural Forecasting Tool) being applied in Oromia.

Finally, the way forward is presented. Considerations for the way forward:

- The issues are mainly operational challenges rather than limitations of the technologies

- Technologies should be founded on the needs of the end users (designing with the users instead of designing for them)
- Raising literacy and digital skills at all levels is critical
- Access to information in local languages can also be a driving factor for farmers, picking up and adopting digital solutions
- Business models for integration of technologies, data analytics and services.

The issue of adoption of PA came to the forefront. What is being understood is that the technology is available; but, the operational challenges are more important.

Presentation 2: Unmanned Aerial Vehicles (UAVs) for Phenotypic Traits Estimation & Yellow Rust Disease Severity Assessment in small-scale Wheat Breeding trials in Ethiopia,

Mr. Tadesse Anberbir

Mr Tadesse presented the results of his testing of UAV at Kulumsa ARC for its potential application in wheat breeding research. The objective of his work was to explore the potential application of UAVs for breeding programs mainly to accelerate genetic gain in wheat breeding programs through mainstreaming high-throughput phenotyping (HTP) platform and digitization into crop breeding programs in Ethiopia. He presented the progress of his work and described the procedures. Sensor technologies and image processing tools employed in the study. The field experiment was done at Bekoji sub-center breeding field trial. The trial was imaged using a Parrot Bluegrass Drone equipped with Sequoia multispectral sensor with a ground sample distance (GSD) of 1.98 cm/px, in five rounds during the main season in the year 2020. The results of the testing showed that UAV-derived data GNDVI (green normalized difference vegetation index) significantly correlated with disease severity scored manually, (R = 0.74 -- 0.84). The study demonstrated that UAV-based imagery methods have greater precision and the potential to replace visual Phenotypic traits estimation and yellow rust disease severity assessment across the breeding data processing pipeline.

Presentation 3: Neural Network Based Model Reference Adaptive Control of Quadrotor UAV for Precision Agriculture,

Mr Muluken Menebo (Addis Ababa University)

The presentation was a review on Neural Network based MRAC as intelligent flight control technique for Quadrotor, and CNN (Conventional Neural Network) as a machine learning approach to recognize severity level of yellow wheat rust for PA. No data were presented.

Presentation 4: Towards developing tailored and location-specific digital agroadvisory decision support tool to support agricultural transformation in Ethiopia, **Dr. Lulseged Desta (CIAT)**

Dr Lulseged discussed the need for a digital agro-advisory decision support tool to support PA. Location specific fertilizer recommendation tool is the most important part of the presentation. The importance of expert advice and research data are discussed. The gap in the application of the system highlighted were: the difficulty to match the available recommendations with the wide differences in the management history due to high, medium, low economic capacity of farmers.

Presentation 5: The role of national agricultural datahub towards precision agriculture,

Dr. Melkmau Beyene (Addis Ababa University)

Dr Melkamu presented the role of national agricultural datahub for development of precision agriculture, focusing on the situation in Ethiopia and the work that is being done on infrastructure. According to him, the system will be operational in a few months' time. The discussion included about the challenges in data acquisition, how to bring agricultural data into the datahub and share among users. The infrastructure resources needed may include raw observation and experimental data and publications. The main question raised and discussed was about data sharing policies. Nonetheless, everyone agreed that the system can ensure the advancement of scientific research and development works and that stakeholders' needs are met. The system can be very helpful to make maximum utilization of data and create new opportunities for data intensive research.

In addition to the oral presentation, 5 posters were again presented, as shown in Figure 2.

Figure 2: poster presentations, day 2, during tea break

General discussion and way forward for PA in Ethiopia

Dr Tolesa Debele chaired the discussion. He raised issues on how to start PA in Ethiopia

- Should be started using one commodity, such as wheat or barley crop.
- EIAR needs to invest at 2 or 3 sites for model precision agriculture (PA) sites: funds should be sought from Govt source and donor organizations.
- Need to organize a team of researchers to prepare proposals for MoA, EIAR and donors.
- The first step is to understand the status of PA in Ethiopia. What components of PA are being implemented? what are the gaps and what can be done to disseminate and implement the system,

Then the stage was opened to the audience. Most of the participants expressed their feelings.

Dr Melkamu Beyene: there is a need to understand the status of our agricultural system and where the gap is for the development of PA under our system. Understanding this issue is very important before going to any project development on PA. In all cases, he is willing to provide any technical assistance for the development of the system in Ethiopia.

Dr Tesfaye Beleme: according to his view, unless MoA owns the issue, there is no way for scaling up the technology. To Dr Tesfaye's comment, Dr Tolesa responded that any new approach is subject to resistance. The resistance on lowland irrigation when it was started was mentioned as an example. Despite the challenges, it is now all accepted in the country. So, policy makers can accept PA when they see the benefits. Dr Tesfaye Beleme also suggested the need for improving

data quality. Data quality is very important. He said that we should provide the necessary attention to data quality. "Data quality for our database is a concern".

Dr Geremew Taye: challenges are expected. Despite this, he said he is committed to provide any assistance for the development of PA under EIAR and expansion of the technology to users.

Dr Dejene Abera: "I am thinking of what to do about PA in Ethiopia". So, it is better to start with awareness creation, as one entry point. Irrigated wheat can be another entry point. The main problem with irrigated wheat is water management. If we start with precise application of water and then fertilizer under off-season irrigation, it will introduce EIAR and the PA team to MoA. He also expressed his readiness to support development of a proposal.

Mr. Yonas Mersha (poster presenter): the conference enabled him to understand that he can work with climate prediction. Technology wise, he is ready to support the team with his capacity on climate issues.

Mr Abebe Hagano: "I am happy that I can be ambassador for PA in my areas in the south regional administration. Although we are far from Addis Ababa, we work with the center on research and development issue".

An invited guest from Addis Ababa University said that staff members already presented 2 activities from Addis Ababa University. The team has the softwares needed and can discuss how to implement the softwares on issues related to climate forecasting for weather variability model sites, etc.

Derib Kifle: Soil health and maintenance is an important issue. We must work on soil health, waterlogging problems, and acid soils management using PA. I am ready to participate in any work related to PA. Satellites, drones and robotics are new to EIAR. It is at an infant stage. There is the need for increased attention.

Dr Lulseged: "We need regular interchange meetings. We need a task force. We need 4 or 5 people to be engaged in the system that includes ICT. Select one entry point. Irrigation can be expensive. Other areas can be considered. Digital data hub is also another area to focus. But, the entry point should be selected. Fertilizer management is one thing. How can we use data from research centers for development of fertilizer recommendations? In addition, it is also necessary to work on capacity building".

Finally, Dr Tolessa Debele, before ending the session stressed on the need for increased attention to development of proposals. "We can think of new things and work together". To wrap up: "what is PA?" Is it precise application of inputs, whatever the input can be, water, fertilizer, pesticide, seed? Cost effective and environmentally sustainable management system? How much US dollar does the country spend every year on fertilizers? How does PA contribute to reducing the expenditure on inputs by increasing efficiency? If PA can save 10% pesticide cost, 10% fertilizer cost, etc, what does it mean to the economy and environment? But, do we have the data to convince the govt on the issue that PA can reduce inputs use and costs? if we do not have, we can obtain data from other countries or generate for ourselves. We need to develop a policy brief from this workshop. There is a need to establish a steering committee at high level, directorate level. Technical committee members can be from EIAR, universities, etc. focal persons from each institute and locations to generate detailed data and supply to the technical committee.

The general discussion session was finalized through consensus made in the following points:

1) We need an entry point: it can be fertilizer, water, under NRM.
2) Fund raising: we need to write a proposal, concept note.
3) Need to develop PA targeted/centered research proposal for 2015 using govt fund
4) Demonstration for policy makers and stakeholders based on the available data at our hands.
5) Lobby and advocacy: advocacy using media, writing for newspapers, publication.
6) Need to have regular meetings: steering committee 2x per year, for technical committee 4x per year.

Acknowledgments

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