UNIVERSITY OF HOHENHEIM

CLIFOOD SDG Graduate School

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German-Ethiopian SDG Graduate School: Climate Change Effects on Food Security (CLIFOOD)

2016–2025

Book of Abstracts

A Compilation of Peer-Reviewed Research by Doctoral Candidates

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October 2025

Citation: Feleke, Hirsut Getachu; Amdie, Tesfaye Abebe; Rasche, Frank; Bahrs, Enno; Schönleber, Nicole; Mersha, Sintayehu Yigrem; and Brandt, Christian. (Eds.) 2025. German-Ethiopian SDG Graduate School: Climate Change Effects on Food Security (CLIFOOD) 2016–2025, Book of Abstracts, A compilation of peer-reviewed research by doctoral candidates. University of Hohenheim and Hawassa University. 61 pp.

This *Book of Abstracts* presents a compilation of 57 peer-reviewed research outputs produced through the CLIFOOD project, a German-Ethiopian SDG graduate school initiative titled *"Climate change effects on food security."* The project is a collaborative partnership between Hawassa University (HU) and the University of Hohenheim (UHOH), supported by the German Academic Exchange Service (DAAD) with funding from the Federal Ministry for Economic Cooperation and Development (BMZ).

CLIFOOD operated in two phases between 2016 and 2025. The primary focus of the project was on empowering young scholars from Ethiopia and the Eastern African region through interdisciplinary research, graduate education, and institutional capacity building aligned with the UN Sustainable Development Goals (SDGs).

Contents

Introduction

The Book of Abstracts compiles 57 peer-reviewed research contributions produced under the German-Ethiopian SDG graduate school “Climate change effects on food security” (CLIFOOD), a collaborative initiative between the University of Hohenheim (UHOH) in Germany and Hawassa University (HU) in Ethiopia. Established in 2016 and supported by the German Academic Exchange Service (DAAD) with funding from the Federal Ministry for Economic Cooperation and Development (BMZ), CLIFOOD has operated in two phases (2016–2020 and 2021–2025) to advance sustainable development through targeted research and capacity building in Eastern Africa.

CLIFOOD addresses two of the most pressing and interlinked challenges of our time: climate change and food insecurity. Grounded in the UN 2030 Agenda and the Sustainable Development Goals (SDGs), the program educates and empowers the next generation of African scholars by strengthening higher education institutions (HEIs) in Ethiopia and the wider Eastern African region. Through interdisciplinary teaching, collaborative research, and institutional development, it equips early-career academics, particularly PhD students and postdoctoral researchers, with the skills to design science-based, locally grounded solutions.

The scientific program spans soil, crop, and livestock sciences, agrometeorology, agroecology, physics, and food and nutrition sciences. This holistic approach reflects the complexity of food systems and the multifaceted impacts of climate change, demanding crosscutting research and partnerships. Phase I (2016–2020) laid the foundation with a robust, interdisciplinary qualification program. Phase II (2021–2025) built on this momentum, intensifying the production of evidence-based knowledge and fostering applied research that directly supports sustainable agriculture, food and nutrition security, and climate resilience.

More than a record of scientific output, this compilation reflects the collaborative spirit, intellectual rigor, and commitment that have characterized CLIFOOD since its inception. By bringing together the voices and findings of young African scholars, the *Book of Abstracts* serves as a testament to the project's impact and a valuable resource for researchers, educators, policymakers, and development practitioners working towards sustainable food systems in a changing climate.

Climate on the edge: Impacts and adaptation in Ethiopia's agriculture

Citation

Feleke, H.G., Abebe, T., Rasche, F., Mersha, S.Y., and Brandt, C. 2025. Climate on the edge: Impacts and adaptation in Ethiopia's agriculture

Abstract

Climate change poses a significant threat to Ethiopian agriculture, affecting cereal and livestock production through rising temperatures, erratic rainfall patterns, prolonged droughts, and increased outbreaks of pests and diseases. These challenges intensify food insecurity, particularly for smallholder farmers and pastoralists who rely on climate-sensitive agricultural systems. This systematic review aims to synthesize the impacts of climate change on Ethiopian agriculture, with a specific focus on cereal production and livestock feed quality, while exploring effective adaptation strategies that can support resilience in the sector. The review synthesizes 50 peer-reviewed publications (2020–2024) from the "Climate change effects on food security" project, which supports young African academics and Higher Education Institutions (HEIs) in addressing the Sustainable Development Goals (SDGs). Using the PRISMA guidelines, this review assesses the impacts of climate change on major cereal crops and livestock feed in Ethiopia and explores adaptation strategies. Over the past 30 years, Ethiopia has experienced rising temperatures (0.3–0.66 °C), with future projections indicating increases of 0.6–0.8 °C per decade, resulting in more frequent and severe droughts, floods, and landslides. These shifts have led to declining yields of wheat, maize, and barley, shrinking arable land, and deteriorating feed quality and water availability, all of which severely affect livestock health and productivity. The study identifies key on-the-ground adaptation strategies, including adjusted planting dates, crop diversification, drought-tolerant varieties, soil and water conservation, agroforestry, supplemental irrigation, and integrated fertilizer use. Livestock adaptations include improved breeding practices, fodder enhancement using legumes and local browse species, and seasonal climate forecasting. These results have significant practical implications: they offer a robust evidence base for policymakers, extension agents, and development practitioners to design and implement targeted, context-specific adaptation strategies. Moreover, the findings support the integration of climate resilience into national agricultural policies and food security planning. The climate change effects on food security project's role in generating scientific knowledge and fostering interdisciplinary collaboration is vital for building institutional and human capacity to confront climate challenges. Ultimately, this review contributes actionable insights for promoting sustainable, climate-resilient agriculture across Ethiopia.

Keywords: climate change; food security; cereal crops; livestock feed; agricultural resilience; policy; sustainable development

DOI: https://www.mdpi.com/2071-1050/17/11/5119

Exploring the relationship between agricultural land use and soil quality: Insights from southern Ethiopia agroecologies

Citation

Geremu, T., Abera, G., Lemma, B., and Rasche, F. 2025. Exploring the relationship between agricultural land use and soil quality: Insights from southern Ethiopia agroecologies

Abstract

In various agroecological zones of Ethiopia, inappropriate soil management, especially under cropland use, has significantly degraded soil quality. However, comprehensive studies examining the impact of land use on soil quality indicators across these zones remain limited. This study aimed to evaluate the impact of various land uses (enset, grazing, faba bean, common bean, potatoes, wheat, barley, maize, and intercropping fields) on soil quality indicators and indices across the agroecologies of southern Ethiopia. One hundred and thirty-two soil samples (0–20 cm depth) were analyzed for soil quality indicators. Analysis of Variance (ANOVA) was used for statistical comparison. Principal Component Analysis (PCA) identified a minimum data set (MDS). Results showed significant ($p < 0.001$) variations in soil quality indicators, with enset land exhibiting the highest levels of pH, organic carbon (OC), total nitrogen (TN), available phosphorus (Pav), exchangeable bases, and CEC, followed by grazing lands.

In contrast, annual croplands had the lowest values except for micronutrients. The PCA analysis indicated that the silt fraction, BD, pH, OC, and Pav were identified as the MDS, accounting for 87.86%, 90.26%, 89.27%, and 86.83% of the variability explained in the soils of Hula, Cheha, Boricha, and Hawassa Zuria, respectively. The soil quality index (SQI) values were moderate to high for enset, low to moderate for grazing, and consistently low for annual crops, which showed the highest nutrient depletion. The aggregated SQI across the different agroecological zones was categorized as low. Customized soil management practices, especially the implementation of site-specific integrated soil fertility management, are crucial for enhancing soil quality and ensuring sustainability in these agroecological zones.

Keywords: *Ensete ventricosum,* minimum data set, organic carbon, soil quality indicators, weighted additive method

DOI: https://doaj.org/article/70a014e3de25492d9cf263c771070fd0

Abundance and symbiotic efficiency of indigenous rhizobia nodulating faba bean and common bean in southern Ethiopia

Citation

Geremu, T., Abera, G., Lemma, B., and Rasche, F. 2025. Abundance and symbiotic efficiency of indigenous rhizobia nodulating faba bean and common bean in southern Ethiopia

Abstract

The symbiotic association between legumes and indigenous rhizobia is crucial for enhancing legume productivity. However, inconsistent results and suboptimal performance of rhizobia inoculation in promoting legume production have been observed. In this regard, we assessed the abundance and symbiotic efficiency of indigenous rhizobia nodulating faba bean and common bean, as well as the soil factors affecting rhizobia abundance in southern Ethiopia. The study also compared the performance of indigenous rhizobia with commercial strains and mineral nitrogen treatment plants. One hundred and thirty-two soil samples were collected from barley, wheat, maize, potato, common bean, faba bean, intercropped common bean and maize, enset, and grazing land. Indigenous rhizobia were isolated and enumerated from these samples. Faba bean (FB) and common bean (CB) rhizobia populations ranged from 0.0 to 1.7×10^4 and 1.7×10^1 to 1.7×10^7 cells g^{-1} soil, respectively. Soil pH, EC, OC, TN, CEC, exchangeable acidity, aluminum, and the host crop occurrence significantly influenced rhizobia populations. The isolated indigenous rhizobia demonstrated significant potential in enhancing nodulation, shoot dry weight, and TN accumulation in plants. Symbiotic efficiency indices revealed that over 95% of the indigenous rhizobia were effective in nodulation and shoot dry matter accumulation, indicating that naturally occurring rhizobia are efficient and may reduce the need for commercial inoculants in areas with abundant indigenous populations. However, in areas where rhizobia populations are low, strains isolated from faba bean (33FB, 84FB) and common bean (44CB, 102CB), which outperformed commercial strains, should be further evaluated. The results suggest that soil rhizobia population levels should be assessed before inoculation to optimize nodulation and crop performance. To this end, it is emphasized that evaluating soil rhizobia strains is important for assessing their stability and competitiveness relative to commercial inoculants across different agroecological conditions.

Keywords: abundance, indigenous rhizobia, *Vicia faba*, *Phaseolus vulgaris*, inoculants, symbiosis

DOI https://doi.org/10.3389/fsoil.2025.1568292

How much to cut? Finding an optimal thinning intensity of encroaching woody species for the herbaceous community in an East African savanna

Citation

Abate, T., Abebe, T., and Treydte, A. 2025. How much to cut? Finding an optimal thinning intensity of encroaching woody species for the herbaceous community in an East African savanna

Abstract

Globally, bush encroachment poses a great threat to the conservation of biodiversity and rangeland productivity. However, control methods of encroaching woody species have rarely been experimentally quantified. We assessed the impact of tree thinning intensities on the mortality of trees and the herbaceous community in Borana rangelands, an Ethiopian savannah ecosystem. At two 1.4 ha areas of mono-specific *Vachellia drepanolobium* stands, we set up 20 m × 10 m experimental plots with four tree-thinning treatments (0%, 33%, 67%, and 100% tree removal), with three replications in a randomized complete block design (RCBD) across two sites. The 0% plot was left uncleared and used as a control. Over two growing periods, we monitored resulting tree mortality, coppicing, seedling mortality, and recruitment, as well as herbaceous layer attributes (diversity and biomass) and rangeland conditions. Tree thinning intensity significantly increased the abundance of the dominant desirable grass species. Total herbaceous and grass species richness, diversity, and biomass were significantly improved under high (100%) and moderate (67%) tree removal intensity. We conclude that tree thinning at moderate intensity (67%) was most effective in enhancing the mortality of encroached trees and improving grass diversity and herbaceous biomass. We emphasize that effective tree thinning requires post-thinning management and repeated bush control measures. Our findings contribute to the development of recommendations on controlling bush encroachment, species restoration, and rangeland productivity in Ethiopian rangelands.

Keywords: bush encroachment, restoration, tree removal, *Vachellia drepanolobium*, Ethiopia

DOI: https://doi.org/10.3389/fevo.2024.1461573

Phenotypic profiling of anchote [*Coccinia abyssinica* (Lam.) Cogn] accessions through agromorphological and physiological markers

Citation

Dibaba, D.B., Olango, T.M., Asfaw, B.T., Mijena, D.F., and Terfa, M.T. 2025. Phenotypic profiling of anchote [*Coccinia abyssinica* (Lam.) Cogn] accessions through agromorphological and physiological markers

Abstract

Anchote (*Coccinia abyssinica*) is a neglected high-potential food and nutrition security tuber crop in Ethiopia. Phenotyping core germplasm collections using agromorphological and physiological markers is essential for effective crop improvement and utilization. Two hundred and eighty-two anchote germplasms were profiled using six qualitative and twenty-six quantitative agromorphological and physiological traits. An augmented block design was used for the experiment at the Debre Zeit Agricultural Research Center. The chi-square test and Shannon diversity index indicated the presence of substantial phenotypic variation and diversity among the accessions based on the predominant qualitative traits studied. The quantitative agromorphological and physiological traits showed wider variability and ranges for the accessions. The broad-sense heritability and genetic advance, expressed as a percentage of the mean, were notably high for quantitative traits such as root yield, vine length, and leaf area index. A significantly positive correlation was observed among agronomically important traits such as root yield and root diameter, as well as root yield and leaf area. Principal component analysis for both qualitative and quantitative traits revealed that ten components accounted for 72.2% of the variation in qualitative traits.

In contrast, nine components accounted for 69.96% of the variation in quantitative traits. The primary contributors to the variations are traits such as root (shape, flesh color, and yield), leaf (color, length, diameter, and area), and fruit (length, diameter, and weight). Furthermore, the accessions were grouped into two and three clusters based on qualitative and quantitative traits, respectively, indicating that quantitative characters were better at differentiating among the accessions. Similarly, the tanglegram showed little similarity between the qualitative and quantitative agromorphological and physiological traits in clustering the accessions. These findings indicate the presence of sizable trait variation among the accessions, which can be exploited as a selection marker to design and facilitate conservation and breeding strategies for anchote.

Keywords: phenotyping, agromorphological, physiological, qualitative, quantitative, accessions, anchote [*Coccinia abyssinica* (Lam.) Cogn]

DOI: https://doi.org/10.3390/plants14152334

Maize–common bean intercropping effects on nitrogen fixation, nutrient uptake, and soil properties in southern Ethiopia

Citation

Yimer, T., Abera, G., Beyene, S., Gizachew, S., and Rasche, F. 2025. Maize–common bean intercropping effects on nitrogen fixation, nutrient uptake, and soil properties in southern Ethiopia

Abstract

Smallholder farmers need to cope with small farm sizes, low soil fertility, and the risks associated with rainfed agriculture, resulting in low productivity. Crop diversification can potentially improve yields and resource use efficiency in these systems. Field experiments were conducted at two sites in southern Ethiopia to determine the effects of common bean (*Phaseolus vulgaris* L.) intercropping time and frequency on biological nitrogen fixation (BNF), nutrient uptake, and soil properties. Treatments included monocrops of maize (M) and common bean (Bn), double common bean mono crop (Bn + Bn), simultaneous (M + Bn), relay (M + BnR), and sequential common bean intercropping with maize (M + Bn + Bn). BNF by common bean under these systems was estimated using the ^{15}N natural abundance method. Intercropping had no significant ($p > 0.05$) effect on BNF compared to common bean monoculture at both sites. However, there were significant differences in BNF among intercropping systems at site 1. Significantly higher BNF were obtained from M+Bn+Bn compared with M + Bn and M + BnR. Intercropping significantly ($p < 0.05$) increased the N and P uptakes compared to unfertilized maize monoculture at both sites, resulting in increased yields but no significant effect on nutrient use efficiencies. Significantly higher N and P uptakes were obtained from M+Bn+Bn compared to other intercropping, and significantly lower N and P uptakes were obtained from M + Bn and M + BnR. Intercropping had no significant ($p > 0.05$) effect on most soil properties, possibly due to the short experimental duration. Therefore, a nutrient management strategy is required in intercropping systems to counteract the increased nutrient uptake, which could lead to soil depletion in the long term, particularly if all biomass is removed from the field.

Keywords: Intercropping, nutrient uptake, soil properties, biological nitrogen fixation

DOI: https://doi.org/10.1002/saj2.70037

Effect of substituting concentrate mix with sweet potato vines on growth performances and carcass components of yearling rams and its potential in mitigating methane production

Citation

Tadesse, A., Titze, N., Rodehutscord, M., and Melesse, A. 2025. Effect of substituting concentrate mix with sweet potato vines on growth performances and carcass components of yearling rams and its potential in mitigating methane production

Abstract

This study was conducted to investigate the substitution effect of the concentrate mix (CM) with sweet potato vine (SPV) on growth performance, carcass characteristics of rams, and methane (CH_4) production. Forty yearling rams with an initial body weight of 18.5±0.7 kg were randomly distributed into five treatment diets with eight rams each. A CM of 385 g head/d was supplied to the control group (SPV0), and diets were formulated to replace the CM of the control diet with SPV at 10% (SPV10), 20% (SPV20), 30% (SPV30), and 40% (SPV40). After 82 days, four rams from each treatment were randomly selected and slaughtered. The CH_4 production was determined from 24-h *in vitro* gas production (GP), and digestible organic matter (DOM) and metabolizable energy (ME) were estimated based on the GP. Data were analyzed using the one-way ANOVA and orthogonal polynomial contrast functions. Results indicated that the contents of the crude protein (CP) and ash in SPV were 258 and 148 g/kg DM, respectively. The substitution of CM with SPV in the *in vivo* trial did not affect body weight gain, feed intake, and feed conversion ratio (FCR). Rams fed with the SPV0 diet had higher ($p < 0.05$) hot carcass weight than those reared in the SPV10, SPV20, and SPV40 diets. The slaughter weight and dressing percentage showed significant linear and quadratic effects. Moreover, significant linear and cubic trends were noted for the hot carcass, thorax, foreleg, and hind leg. The SPV0 diet had the highest GP ($p < 0.001$) compared to the SPV30 and SPV40 diets. The SPV40 diet and the pure SPV had the lowest CH_4 production ($p < 0.001$). The SPV0 diet showed similar ME with SPV10 and SPV20 diets but was higher ($p < 0.001$) than the SPV30 and SPV40 diets, and pure SPV. The DOM did not differ between treatment diets. Similarly, the DOM of SPV did not differ ($p > 0.05$) from that of the SPV30 and SPV40 diets. In conclusion, replacing CM with SPV significantly reduced the *in vitro* CH_4 production without affecting voluntary feed intake, weight gain, some carcass components, and DOM.

Keywords: carcass cuts, methane mitigation, potato vine, sheep, weight gain

DOI: https://doi.org/10.1155/vmi/1054348

Effects of *Prosopis juliflora* pods on sheep performance and carcass traits, and their methane mitigation potential as assessed *in vitro*

Citation

Tadesse, A., Titze, N., Rodehutscord, M., and Melesse, A. 2025. Effects of *Prosopis juliflora* pods on sheep performance and carcass traits, and their methane mitigation potential as assessed *in vitro*

Abstract

This study aimed to assess the effect of partial substitution of concentrate mix (CM) with *Prosopis juliflora* pod (PJP) on growth performance and carcass traits in sheep, as well as its potential to reduce methane (CH_4) production *in vitro*. Twenty-five yearling rams with an initial body weight of 15.8±1.53 kg were randomly assigned to five treatment diets. The diets consisted of a control diet (JP0) and JP0 replaced with PJP at levels of 5% (JP5), 10% (JP10), 15% (JP15), and 20% (JP20). Data were collected on feed intake, body weight, and carcass characteristics. Methane production was determined from 24 h of *in vitro* gas production. The substitution of CM with PJP did not affect feed intake, body weight, weight gain, feed efficiency, and carcass traits ($p > 0.05$). The *in vitro* CH_4 production was reduced ($p < 0.001$) in diets containing increased levels of PJP. The metabolizable energy for JP10, JP15, and JP20 diets was 11.9, 11.6, and 11.5 MJ/kg DM, respectively ($p > 0.05$). In conclusion, replacing CM with PJP did not negatively affect growth performance or carcass characteristics, and it could be used as a potential supplement to mitigate methane emissions. Further *in vivo* studies involving respiration chambers are recommended to investigate the CH_4 reduction potential of PJP.

Keywords: growth performance, carcass characteristics, methane production, *Prosopis juliflora* pod, yearling rams

https://doi.org/10.1080/09712119.2025.2540909

Unveiling wheat's future amidst climate change in the Central Ethiopia Region

Citation

Senbeta, A.F., Worku, W., Gayler, S., and Naimi, B. 2024. Unveiling wheat's future amidst climate change in the Central Ethiopia Region

Abstract

Quantifying the impact of climate change on wheat production and accurately predicting its potential distributions in the face of future climate change are highly important for ensuring food security in Ethiopia. This study leverages advanced machine learning algorithms, including random forest, MaxEnt, boosted regression tree, and generalized linear model, alongside an ensemble approach to accurately predict shifts in wheat habitat suitability in the Central Ethiopia Region over the upcoming decades. An extensive dataset comprising 19 bioclimatic variables (Bio1–Bio19), elevation, solar radiation, and topographic positioning index was refined by excluding collinear predictors to enhance model accuracy. The analysis revealed that the precipitation of the wettest month, the minimum temperature of the coldest month, temperature seasonality, and precipitation of the coldest quarter are the most influential factors, which collectively account for a significant proportion of habitat suitability changes. The future projections revealed that up to 100% of the regions currently classified as moderately or highly suitable for wheat could become unsuitable by 2050, 2070, and 2090, illustrating a dramatic potential decline in wheat production. Generally, the future of wheat cultivation will depend heavily on developing varieties that can thrive under altered conditions; therefore, immediate and informed action is needed to safeguard the region's food security.

Keywords: central Ethiopia region, climate scenarios, habitat suitability, species distribution models, wheat

DOI: https://doi.org/10.3390/agriculture14081408

Spatiotemporal climate variability and food security implications in the Central Ethiopia Region

Citation

Senbeta, A.F., Worku, W., and Gayler, S. 2024. Spatiotemporal climate variability and food security implications in the Central Ethiopia Region

Abstract

Studies focusing on the spatiotemporal distribution of climatic parameters and meteorological drought are of paramount significance for countries like Ethiopia, where climate change and variability lead to significant losses in rain-dependent agriculture. In this study, the National Meteorology Institute of Ethiopia provided an Enhanced National Climate Services (ENACTS) dataset at a spatial resolution of approximately 4 km by 4 km over 38 years (1981–2018), which was used to study climate trends, spatiotemporal variability, and meteorological drought in the Central Ethiopia Region. Coefficient of variation (CV), standardized rainfall anomaly (SRA), standardized precipitation index (SPI), Mann-Kendall trend test, and Sen's slope were used for the analysis. The findings suggest that Belg rainfall (also known as "small-rain") varied greatly in space and time over the study area, with an area-averaged CV of 29% and pixel-level CVs ranging from 63% to 93%. The average precipitation during the Belg season experienced a 15% decrease from 2000 to 2019 compared to the preceding two decades, from 1981 to 1999. The maximum temperature has increased significantly during the Annual, Belg, and Bega seasons. The SPI and SRA indicated that multiple drought episodes have occurred, characterized by rising negative rainfall anomalies, with a drought event every 2.9 years during the Kiremt (known as the "big rain," spanning from June to September) and Belg seasons. The growing negative rainfall anomaly, high CV, and highly significant increase in mean maximum temperature during the Belg season are concerning for food security and poverty eradication. The notable rise in rainfall during June (the sowing period) and November (the harvesting period) also negatively impacts crop production during the main cropping season. Thus, developing appropriate adaptation strategies and policies oriented toward climate-resilient agriculture is crucial to meeting the global Sustainable Development Goals (SDGs) and the African Union's Agenda.

Keywords: ENACTS, meteorological drought, precipitation, temperature, trend, variability

DOI: https://doi.org/10.1016/j.sciaf.2024.e02390

Assessment of seasonal rainfall prediction in Ethiopia: Evaluating a dynamic recurrent neural network to downscale ECMWF-SEAS5 rainfall

Citation

Kebede, A., Warrach-Sagi, K., Schwitalla, T., Wulfmeyer, V., Abebe, T., and Ware., M. 2024. Assessment of seasonal rainfall prediction in Ethiopia: Evaluating a dynamic recurrent neural network to downscale ECMWF-SEAS5 rainfall

Abstract

Seasonal rainfall plays a crucial role in both environmental dynamics and decision-making for rainfed agriculture in Ethiopia, a country frequently affected by extreme climate events, including drought and floods. Predicting the onset of the rainy season and providing localized rainfall forecasts for Ethiopia is challenging due to the country's changing spatiotemporal patterns and rugged topography. The Climate Hazards Group InfraRed Precipitation with Station Data (CHIRPS), ERA5-Land total precipitation and temperature data are used from 1981 to 2022 to predict spatial rainfall by applying an artificial neural network (ANN). The recurrent neural network (RNN) is a nonlinear autoregressive network with exogenous input (NARX), which includes feed-forward connections and multiple network layers, employing the Levenberg-Marquardt algorithm. This method is applied to downscale data from the European Centre for Medium-range Weather Forecasts fifth-generation seasonal forecast system (ECMWF-SEAS5) and the Euro-Mediterranean Centre for Climate Change (CMCC) to the specific locations of rainfall stations in Ethiopia for the period 1980–2020. Across the stations, the results of NARX exhibit strong associations and reduced errors. The statistical results indicate that, except for the southwestern Ethiopian highlands, the downscaled monthly precipitation data exhibit high skill scores compared to the station records, demonstrating the effectiveness of the NARX approach for predicting local seasonal rainfall in Ethiopia's complex terrain. In addition to this spatial ANN of summer season precipitation, temperature, and their combination, these two variables show promising results.

Keywords: station, prediction, downscaling, artificial neural networks, rainfall

DOI: https://doi.org/10.1007/s00376-024-3345-1

Effect of substituting concentrate mix with *Cajanus cajan* leaf on growth performance traits and carcass components of yearling rams and its potential in mitigating methane production

Citation

Tadesse, A., Melesse, A., Titze, N., and Rodehutscord, M. 2024. Effect of substituting concentrate mix with *Cajanus cajan* leaf on growth performance traits and carcass components of yearling rams and its potential in mitigating methane production

Abstract

The primary challenges in ruminant production are to reduce feeding costs and to improve product quality with minimal environmental impact. The use of unconventional feedstuffs may help decrease feeding costs and environmental impact. A study was conducted to investigate the supplementation effect of *Cajanus cajan* leaves (CCL) on the growth performance and carcass characteristics of yearling rams, as well as their association with CH_4 reduction *in vitro*. Thirty yearling rams with an initial body weight of 15.1±0.68 kg were randomly allocated into five treatment diets with six rams each. A basal diet was prepared to contain 300 g/head/d concentrate mix (CM) for the control group (T1), and treatment (T) diets were formulated by replacing the CM with CCL at 5% (T2), 10% (T3), 15% (T4), and 20% (T5). Data were collected on feed intake, body weight, carcass, and CH_4 production from 24h *in vitro* gas production (GP). The DOM and ME were estimated from 24-h GP. The analyzed ash, ether extract, and crude protein contents of the CCL were 126, 43, and 240 g kg^{-1} DM, respectively. The feed intake, body weight gain, feed efficiency, and carcass components were not affected by treatment diets. The 24-h GP (ml g^{-1} DM) was significantly higher for T1 and T2 diets than for T4 and T5. The lowest CH_4 was obtained from T5 and differed significantly from that of T1 and T2. The ME and DOM values in the T1 and T2 diets were higher than those of T4 and T5. The supplementation of CCL considerably reduced CH_4 production across treatment diets without affecting voluntary feed intake, weight gain, or carcass components, suggesting its potential as an alternative supplement to poor-quality forages while maintaining a minimal CH_4 production level.

Keywords: body weight, feed intake, carcass, methane production, pigeon pea, yearling ram

DOI: https://doi.org/10.17170/kobra-202403129761

Characterization of complementary feeding practice and locally available climate-resilient crops for complementary food among agropastoralists of Ethiopia: A qualitative study

Citation

Desta, D.T., Teferra, T.F., and Gebremedhin, S. 2024. Characterization of complementary feeding practice and locally available climate-resilient crops for complementary food among agropastoralists of Ethiopia: A qualitative study

Abstract

The current study aims to characterize complementary feeding practices and identify locally available, climate-resilient crops that can be used for complementary feeding among agropastoralists in Ethiopia. A phenomenological study was conducted in the Benna-Tsemay district, comprising focused group discussions, key informant interviews, and household observations. A pretested guide was used to collect information on the types of complementary food, lists of food items, and ingredients included in their complementary formulations. A thematic analysis was conducted to identify emerging points of discussion. Three major themes emerged, including infant and young child feeding practices, the food items included in complementary foods, and their consumption frequencies, as well as the incorporation of climate-resilient crops into complementary foods as coping mechanisms. Breastfeeding was common and regarded as essential. Gruel and porridge from grains, roots, and tubers were regular parts of complementary foods in the study area. Moringa and sorghum were dominantly identified as climate-resilient crops regularly grown and used in complementary foods. Growing these crops was regarded as a coping strategy for drought and seasonal constraints. The district is one of the most drought-prone areas in Ethiopia, compromising the quality of complementary food. Unlike the World Health Organization recommendation, the grains, roots, and tubers-based diet formed the basis of complementary food, lacking flesh foods, eggs, pulses, and other fruits and vegetables. Thus, it is recommended to enhance the quality of complementary food through value addition using locally accessible crops.

Keywords: Agropastoralists; children; climate-resilient crops; complementary food; food group; moringa; sorghum

DOI: https://doi.org/10.1017/jns.2024.53

The effect of rainfall and temperature patterns on childhood linear growth in the tropics: Systematic review and meta-analysis

Citation

Desta, D.T., Teferra, T.F., and Gebremedhin, S. 2024. The effect of rainfall and temperature patterns on childhood linear growth in the tropics: Systematic review and meta-analysis

Abstract

Despite existing research on child undernutrition in the tropics, a comprehensive understanding of how weather patterns impact childhood growth remains limited. This study summarizes and estimates the effect of rainfall and temperature patterns on childhood linear growth among under-fives in the tropics. Forty-one out of 829 studies were considered based on preset inclusion criteria. Standardized regression coefficients (β) were used to estimate effect sizes, which were subsequently pooled, and forest plots were generated to visually represent the effect size estimates along with their 95% confidence intervals. Of the total reports, 28 research articles were included in the narrative synthesis and 13 were included in the meta-analysis. The studies establish that patterns in rainfall and temperature either increase or decrease childhood linear growth and the risk of stunting. An increase in everyone's standard deviation of rainfall results in a 0.049 standard deviation increase in linear growth (β = 0.049, 95% CI: 0.024 to 0.073). Various factors likely mediated this positive association. In countries where agriculture is heavily dependent on rainfall, increased precipitation can lead to higher crop yields, which could in turn result in improved food security. The improved food security has a positive impact on childhood nutrition and growth. However, the extent to which these benefits are realized can vary depending on moderating factors such as location and socioeconomic status. The temperature pattern showed a negative correlation with linear growth, where each standard deviation increase resulted in a decrease in linear growth of 0.039 standard deviations, with specific impacts varying by regional climate (β = −0.039, 95% CI: −0.065 to −0.013).

Additionally, our meta-analysis reveals a small but positive relationship between childhood stunting and temperature patterns in Western Africa (β = 0.064, 95% CI: 0.035, 0.093). This association is likely due to the indirect effects of temperature patterns on food security and increased disease burden. Thus, the intricate interaction between weather patterns and linear growth in childhood requires further research to distinguish the relationship, considering other factors in the global tropics. While our findings provide valuable insights, they are primarily based on observational studies from sub-Saharan Africa and may not be generalizable to other tropical regions.

Keywords: temperature; rainfall; stunting; tropics; under-five; weather

DOI: https://doi.org/10.3390/ijerph21101269

Feeding values of indigenous browse species and forage legumes for the feeding of ruminants in Ethiopia: A meta-analysis

Citation

Belete, S., Tolera, A., Betsha, S., and Dickhöfer, U. 2024. Feeding values of indigenous browse species and forage legumes for the feeding of ruminants in Ethiopia: A meta-analysis

Abstract

The foliage of browse species and forage legumes has good nutritional value and can be utilized as a protein source in ruminant diets. However, its efficient utilization requires the establishment of a comprehensive database of feeding values. Two databases, namely, forage nutritive value (based on 92 studies) and in vivo animal performance (comprising 62 feeding experiments), were constructed to evaluate the feeding value of the foliage of browse species and cultivated forage legumes in Ethiopia. The forage nutritive value data (chemical composition and in vitro digestibility) were summarized as descriptive statistics. The analysis of in vivo data was conducted using a mixed model procedure with fixed (forage supplement) and random (studies) factors. Forage categories had crude protein (CP) ranging from 17.6±5.2% (indigenous browse species) to 22.4±4.5% (multipurpose fodder tree/shrub species), respectively. Variations were observed in CP values between the vegetative and blooming stage harvesting of herbaceous forages (22.7±4.1% versus 19.8±3.5%). The leaves contained more CP than the twigs in multipurpose fodder tree/shrubs (22.8±3.2% versus 18.8±0.6%) and the pods in indigenous browse species (18.0±5.0% versus 15.3±2.3%). However, the greatest mean *in vitro* organic matter digestibility (IVOMD) of 70.1±10.8% was observed in the foliage of indigenous browse species. The variation in IVOMD was small among the forage categories (61.2±11.2%–63.5±10.8%). Twigs of the multipurpose fodder tree/shrub species had the lowest IVOMD of 53.0±6.9%. Herbaceous forage legumes tended to have higher NDF and ADF values than the other forage categories. In terms of nutrient concentration and digestibility, large variations were observed within the same forage categories and species. The supplementation of forage, on average at 277.5±101.4 g/day (±SD), to a low-quality basal diet resulted in a significant ($p < 0.05$) improvement in the apparent digestibility of DM, CP, and NDF as well as the daily intake of DM, CP, and metabolizable energy (ME). The application of sole forage supplementation was determined to have comparable effects on DM intake ($p = 0.2347$) with dietary supplements based on concentrate feedstuffs. However, CP intake ($p = 0.0733$) tended to be lower for the forage over the concentrate treatment. The average daily gain (ADG) of the animals was significantly increased ($p < 0.05$) by 71.2% due to the forage supplement compared to unsupplemented treatment (11.6±5.47 g/d (±SE) vs. 40.3±4.99 g/d (±SE)). Overall, the nutrient utilization and production performance of animals fed low-quality basal diets can be improved by supplementing with an appropriate amount of forage. The large variation recorded in the nutritional composition of browse species and forage legumes could provide an opportunity to screen for species and varieties with superior nutritional quality.

Keywords: forage legumes, browse species, ruminants, forage supplementation

DOI: https://doi.org/10.3390/agriculture14091475

Symbiotic N_2 fixation in cowpea varieties is markedly enhanced by inoculation with elite *Bradyrhizobium* strains

Citation

Ayalew, T., Yoseph, T., and Cadisch, G. 2024. Symbiotic N_2 fixation in cowpea varieties is markedly enhanced by inoculation with elite *Bradyrhizobium* strains

Abstract

Because of its excellent ability to fix atmospheric nitrogen, cowpea [*Vigna unguiculata* (L.) Walp] makes a significant contribution to soil sustainability and productivity in the resource-limited tropical regions. However, due in part to ineffectiveness and limited availability of bio-inoculant, its symbiotic N contribution and yield remained low in the field. Therefore, this study examined the effect of elite cowpea infecting *Bradyrhizobium* strains (CP-24 and CP-37) on shoot biomass and symbiotic nitrogen contributions of four cowpea varieties (Keti, TVU, black eye bean, and White Wonderer Trailing). For this purpose, a two-year field experiment was conducted at three sites using a factorial randomized complete block design with four replications. The natural abundance of the ^{15}N technique was used to compute the symbiotic N contribution. *Bradyrhizobium* inoculation resulted in significantly higher nodule formation, % Ndfa, N fixation amounts, and shoot biomass, demonstrating the effectiveness and ability of the strains to enhance soil fertility. Inoculating cowpea with the CP-24 strain increased shoot N content, % Ndfa, and N fixed by 40%, 15%, and 41%, respectively, in comparison to the uninoculated control.

Furthermore, the inoculant by variety interaction had a significant effect on nodule number, nodule dry weight, and the amount of N fixed, with TVU and White Wonderer Trailing in combination with CP-24 exhibiting the most outstanding performance. There was also a strong positive correlation between biomass accumulation and N fixed, as well as N fixed and seed yield. Therefore, *Bradyrhizobium* inoculation on cowpea varieties TVU and White Wonderer Trailing, using the CP-24 strain, is recommended at all three tested sites and in similar agroecologies for improved symbiotic N contribution and an associated yield advantage for cowpea. This study highlights that the use of elite and crop-specific *Brady rhizobium* strains can boost symbiotic nitrogen contribution, soil fertility, and the yield performance of legumes. Thus, it helps resource-poor farmers who are struggling with rising mineral fertilizer costs to achieve food security while mitigating climate change risks.

Keywords: Crop varieties, Legume symbiosis, Rhizobacteria strains, Rhizosphere, *Vigna unguiculata*

DOI: https://doi.org/10.1016/j.rhisph.2024.100976

Do we need post-tree thinning management? Prescribed fire and goat browsing to control woody encroacher species in an Ethiopian savanna

Citation

Abate, T., Abebe, T., and Treydte, A. 2024. Do we need post-tree thinning management? Prescribed fire and goat browsing to control woody encroacher species in an Ethiopian savanna

Abstract

Worldwide, bush encroachment threatens rangeland ecosystem services, including plant biodiversity and forage for livestock. Various control methods for encroaching woody species and restoring herbaceous vegetation exist but have rarely been explored experimentally. We assessed the impact of post-tree thinning management on tree mortality, the herbaceous community, and overall rangeland condition in Borana, an Ethiopian savanna ecosystem. At two 1.4 ha areas of encroached mono-specific *Vachellia drepanolobium* (whistling thorn) stands, we set up twenty-four 20 × 10 m experimental plots with four post-tree-thinning treatments (goat browsing only (1), prescribed fire (2), fire and goat browsing (3), and control (4) (i.e., no management after tree cutting), with three replications in a complete block design. Over two growing periods, we monitored resulting tree mortality, coppicing, seedling mortality and recruitment, as well as herbaceous layer attributes (diversity and biomass) and overall rangeland condition. All three post-tree thinning management scenarios significantly enhanced tree mortalities, reduced seedling recruitment, and increased the abundance of the dominant desirable grass species. Prescribed fire and fire and goat-browsing treatments resulted in significantly greater grass and forb species richness, forb diversity, and biomass, as well as overall rangeland condition, compared to the goat-browsing-only and the control treatment. However, the diversity of grass species did not respond to the treatments. Post-tree management significantly increased tree mortality, reduced seedling recruitment, and increased the abundance of desirable grass species. Our findings strongly suggest that post-thinning management, particularly prescribed fire or a combination of fire and browsing, is highly effective in suppressing woody encroachment and improving biomass and overall rangeland condition.

Keywords: bush encroachment, herbivores, rangeland condition, *Vachella drepanolobium*, Ethiopia

DOI: https://doi.org/10.3389/past.2024.13039

Unlocking the potential of inoculation with *Bradyrhizobium* for enhanced growth and symbiotic responses in soybean varieties under controlled conditions

Citation

Beruk, H., Yoseph, T., and Ayalew, T. 2024. Unlocking the potential of inoculation with *Bradyrhizobium* for enhanced growth and symbiotic responses in soybean varieties under controlled conditions

Abstract

Soybeans are a crucial crop for sustainable agricultural development, as they form symbiotic relationships with rhizobia species. The effectiveness of inoculants in symbiosis, however, relies on the compatibility of the strain with a specific legume crop variety. This study assessed the symbiotic efficiency of eight *Bradyrhizobium* strains (SB-36, SB-37, SD-47, SD-50, SD-51, SD-53, SB-113, and SB-120) with five soybean varieties (Gishama, Awassa-95, Boshe, Hawassa-04, and Jalale) using sand culture. The experiment was arranged in a factorial, completely randomized design with three replicates. Data were collected on plant growth and symbiotic effectiveness indices and subjected to statistical analysis using R software v4.3.1. The results revealed marked differences ($p < 0.001$) between the varieties, rhizobial strains, and their combined effects on all traits examined. The Jalale variety inoculated with *Bradyrhizobium* strains SB-113 and SD-53 produced the highest nodules per plant. When inoculated with SD-53, Awassa-95 demonstrated the highest relative symbiotic effectiveness [129.68%], closely followed by the Boshe variety [128.44%] when inoculated with the same strain. All strains exhibited high relative symbiotic effectiveness (>80%) with Awassa-95 and Boshe varieties. The highest absolute symbiotic effectiveness was observed in the Gishama variety inoculated with the SD-53 strain, followed by Boshe and Awassa-95 varieties inoculated with this same strain. Notably, strain SD-53 demonstrated remarkable efficiency with the varieties Gishama, Boshe, and Awassa-95 based on both relative and absolute symbiotic effectiveness indices. Varieties inoculated with the SD-53 strain produced deeper green leaves. This study revealed the importance of *Bradyrhizobium* inoculation in improving soybean performance, with the SD-53 strain performing best among the strains considered in the current experiment. Therefore, it is plausible to recommend inoculating soybeans with *Bradyrhizobium* strain SD-53 with prior field evaluation.

Keywords: absolute symbiotic efficiency, growth, nodulation, relative symbiotic efficiency, strains effectiveness

DOI: https://doi.org/10.3390/agronomy14061280

Combined inoculation of arbuscular mycorrhiza fungi with Meso-rhizobium improves nutrient uptake, growth performance, and moisture stress tolerance of chickpea (*Cicer arietinum* L.)

Citation

Yimer, T., Abera, G., Beyene, S., Bono, B., and Rasche, F. 2024. Combined inoculation of arbuscular mycorrhiza fungi with Meso-rhizobium improves nutrient uptake, growth performance, and moisture stress tolerance of chickpea (*Cicer arietinum* L.)

Abstract

Biofertilizers can serve as better alternatives to chemical fertilizers, enhancing plant nutrition and productivity by improving soil fertility and crop yields in an eco-friendly and cost-effective manner. A pot experiment was conducted between December 2018 and March 2019 in southern Ethiopia to evaluate the combined inoculation of arbuscular mycorrhizal fungi (AMF) and Meso-rhizobium (MR) on biomass yield, nutrient uptake, and moisture stress tolerance of chickpea (*Cicer arietinum* L.) (Variety Habru). The experiment was executed as a factorial arrangement using a completely randomized design with three replications. The treatments were control (non-fertilized), sole AM fungi inoculation, AM fungi inoculation with phosphorus fertilizer (20 kg P ha^{-1}) and MR, and sole inorganic fertilizers (20 kg P;10 kg N ha^{-1}) at four different moisture levels (optimum throughout the growing season, stressed at vegetative, flowering, and seed filling stages). The results demonstrated that biomass yields were limited by moisture stress, particularly during the vegetative and flowering stages of chickpea. The sole and co-application of AMF with MR and inorganic P increased biomass yields on average by 19%, 39%, and 33%, respectively, under water stress conditions, compared to the non-inoculated control. The application of AMF with MR and inorganic P also significantly increased nodulation, AMF colonization, and nutrient uptake. However, these effects were dependent on the soil moisture status. There are potential advantages to be gained from sole and combined AMF application with rhizobium to improve growth and productivity of chickpea through enhanced nutrient and water uptake. However, the results of this pot experiment should be validated through field trials.

Keywords: biofertilizer, moisture uptake, biomass yield, nutrient uptake

DOI: https://doi.org/10.1002/agg2.2056

Optimizing fertilization schemes to narrow the maize yield gap in smallholder farming systems in southern Ethiopia

Citation

Yimer, T., Abera, G., Beyene, S., Ravensbergen, A.P.P. Ukato, A. and Rasche, F. 2024. Optimizing fertilization schemes to narrow the maize yield gap in smallholder farming systems in southern Ethiopia

Abstract

Maize (*Zea mays* L.) is an important food crop in Ethiopia, but its productivity is low primarily due to low soil fertility and inadequate fertilization. Therefore, this study aims to determine the yield, nutrient use efficiency, and economic feasibility of maize production under various fertilizer applications, and to test the suitability of the Quantitative Evaluation of Fertility in Tropical Soils (QUEFTS) model for predicting maize yield responses to fertilization in the Sidama region of southern Ethiopia. On-farm experiments were conducted at six sites (sites 1–6) of the Sidama region, southern Ethiopia, during the 2019 growing season. The experiments were laid out in a randomized complete block design (RCBD) with three replications. The experiment was a nutrient omission trial with seven treatments: control, two full NPK treatments, and four nutrient omission treatments with contrasting N and P rates. Omitting N resulted in a 5–28% yield loss, and omitting P resulted in a 4–44% yield loss compared to the lower rate of full NPK treatment across all study sites.

Meanwhile, omitting K resulted in 21% yield loss only at sites two and three. An increase in maize yield was mainly associated with an increase in both nutrient uptake and nutrient use efficiency of NPK. The results indicated the need to revise blanket recommendations, as the highest mean grain yields and net economic returns, along with acceptable marginal rates of return, were achieved with NPK application or higher levels of NP (N2P2 treatment). In addition, the present QUEFTS model validation study revealed a good fit between the QUEFTS model-predicted maize grain yields (6.3 t ha^{-1}) and the average actual yields (7.4 t ha^{-1} value of RMSE = 1.5 t ha^{-1}), and a small average also confirmed this, and PBIAS = 6.9%. Thus, the model can be a promising option for developing site-specific fertilizer recommendations under smallholder farming systems of the region.

Keywords: Yield response, Fertilizer, Nutrient use efficiency, QUEFTS model

DOI: https://doi.org/10.1016/j.heliyon.2024.e33926

Substitution of soyabean meal with *Moringa stenopetala* leaf meal positively influenced feed consumption and egg production: A novel approach to enhance poultry products in the rural communities

Citation

Beriso, K., Sommerfeld, V., Rodehutscord, M., and Melesse, A. 2024. Substitution of soyabean meal with *Moringa stenopetala* leaf meal positively influenced feed consumption and egg production: A novel approach to enhance poultry products in the rural communities

Abstract

Moringa stenopetala is endemic to Ethiopia, where it is widely distributed in the southern parts of the country. One of the limiting factors in poultry nutrition in the tropics is the availability and accessibility of protein supplements, such as soybean meal, which is considered a primary protein source in poultry nutrition. The objective of this study was thus to evaluate the efficiency of substituting soybean meal (SBM) with graded levels of *Moringa stenopetala* leaf meal (MSL) on feed consumption and egg production performances of Lohmann-tradition chicken breeds. A diet was formulated to contain MSL at rates of 0% (MSL0), 3% (MSL3), 8% (MSL8), and 13% (MSL13) by replacing the soybean meal in the control diet. Diets were formulated to be isocaloric and isonitrogenous with similar energy density and protein level. Forty pre-laying pullets of the Lohmann-tradition chicken breed were randomly distributed to each treatment diet, replicated four times, with ten hens per replicate. Data were collected on egg number, egg weight, and feed intake between 20 and 28 weeks of the hen's age daily. The rate of hen housed egg production (HhEp), egg mass (EM), and feed conversion ratio (FCR) were computed. The substitution of SBM with MSL did not affect HhEp, egg weight, EM, and FCR. The average daily feed intake per hen reared in MSL0, MSL3, MSL8, and MSL13 diets was 112, 109, 119, and 125 g, respectively, being higher ($p < 0.05$) for hens fed with the MSL13 diet than those of the MSL0 and MSL3 diets. The respective individual HhEP for hens fed the MSL0, MSL3, MSL8, and MSL13 diets was 61.0%, 58.5%, 63.3%, and 58.3% respectively. The mean egg weight of hens reared in MSL0, MSL3, MSL8, and MSL13 diets was 53.5, 53.3, 54.1, and 53.5 g, respectively. Hens fed with MSL0, MSL3, MSL8, and MSL13 diets produced 1.60, 1.53, 1.68, and 1.54 kg EM per hen, respectively. The FCR of hens fed on MSL0, MSL3, MSL8, and MSL13 diets was 3.39, 3.46, 3.40, and 3.94 kg feed/kg EM, respectively. It can be concluded that the MSL was more palatable and could effectively substitute up to 15% of the costly SBM as a protein source in the layer hens' diet under tropical production environments.

Keywords: Egg production, feed consumption, Lohmann-tradition chickens, *Moringa stenopetala*, soybean meal

https://www.tropentag.de/2024/abstracts/links/Melesse_ukHKVC8a

High-resolution CMIP6 climate projections for Ethiopia using the gridded statistical downscaling method

Citation

Rettie, F.M,; Gayler, S., Weber, T.K., Tesfaye, K., and Streck, T. 2023. High-resolution CMIP6 climate projections for Ethiopia using the gridded statistical downscaling method

Abstract

High-resolution climate model projections for a range of emission scenarios are needed for designing regional and local adaptation strategies and planning in the context of climate change. To this end, future climate simulations from global circulation models (GCMs) are the primary sources of critical information. However, these simulations are not only coarse in resolution but also associated with biases and high uncertainty. To make the simulations useful for impact modeling at the regional and local level, we utilized the bias correction constructed analogues with quantile mapping reordering (BCCAQ) statistical downscaling technique to produce a 10 km spatial resolution climate change projections database based on 16 CMIP6 GCMs under three emission scenarios (SSP2-4.5, SSP3-7.0, and SSP5-8.5). The downscaling strategy was evaluated using a perfect sibling approach, and detailed results are presented by considering two contrasting GCMs (the worst- and best-performing models) as a showcase. The evaluation results demonstrate that the downscaling approach substantially reduces model biases and generates higher-resolution daily data compared to the original GCM outputs.

Keywords: BCCAQ, CMIP6, downscaling, precipitation, temperature

DOI: https://doi.org/10.1038/s41597-023-02337-2

Comprehensive assessment of climate extremes in high-resolution CMIP6 projections for Ethiopia

Citation

Rettie, F.M., Gayler, S., Weber, T.K., Tesfaye, K., and Streck, T. 2023. Comprehensive assessment of climate extremes in high-resolution CMIP6 projections for Ethiopia

Abstract

Climate extremes have far more devastating effects than the mean climate shift, particularly on the most vulnerable societies. Ethiopia, with its limited economic adaptive capacity, has been experiencing recurrent climate extremes for an extended period, resulting in devastating impacts and acute food shortages that affect millions of people. In the face of ongoing climate change, the frequency and intensity of climate extreme events are expected to increase further in the foreseeable future. This study provides an overview of projected changes in climate extremes indices based on downscaled high-resolution (i.e., 10 × 10 km^2) daily climate data derived from global climate models (GCMs). The magnitude and spatial patterns of trends in the projected climate extreme indices were examined under a range of emission scenarios, known as Shared Socioeconomic Pathways (SSPs). The performance of the GCMs to reproduce the observed climate extreme trends in the base period (1983–2012) was evaluated, the changes in the climate projections (2020–2100) were assessed, and the associated uncertainties were quantified. Overall, results show largely significant and spatially consistent trends in the projected temperature-derived extreme indices with acceptable model performance in the base period. Uncertainties in the GCMs dominated the projected changes at the beginning of the projection period.

In contrast, proportional uncertainties arise from both the GCMs and the SSPs by the end of the century. The results for precipitation-related extreme indices are heterogeneous in terms of spatial distribution, magnitude, and statistical significance coverage. Unlike the temperature-related indices, the uncertainty from internal climate variability constitutes a considerable proportion of the total uncertainty in the projected trends. Our work provides comprehensive insight into projected changes in climate extremes at a relatively high spatial resolution, and the related sources of projection uncertainties.

Keywords: climate extremes, CMIP6, Ethiopia, precipitation, SSPS, temperature, uncertainty, trend

DOI: https://doi.org/10.3389/fenvs.2023.1127265

Regional-scale evaluation of uncertainty in the multi-model simulation of climate change impact on maize and wheat yield

Citation

Rettie, F.M., Gayler, S., Weber, T.K., Tesfaye, K., Bendel, D., and Streck, T. 2023. Regional-scale evaluation of uncertainty in the multi-model simulation of climate change impact on maize and wheat yield

Abstract

The challenges of climate change, even under the milder scenarios, require urgent adaptation and mitigation strategies. While quantifying the potential impacts of climate change involves modeling work, providing decision-relevant evidence is challenging due to the many sources of uncertainty involved in the estimation process. In this study, we examined the regional-scale impact of climate change on maize and wheat in Ethiopia using three well-calibrated and validated process-based crop models. The crop models were driven by gridded and high-resolution climate projections from nine global climate models (GCMs) under three emission scenarios, considering the CO_2 fertilization effect. The large ensemble of model simulations allows us to quantify the uncertainties in the model-estimated climate change impact, thereby increasing confidence in the simulations. Our results show that the national projected median and fifth percentile wheat yield were reduced by 4% and 18%, respectively, by the end of the 21st century under the high-emission scenario (SSP5-8.5).

In contrast, national maize median yield increased by 2.5%, with the fifth percentile yield projected to decrease by up to 4%. CO_2 fertilization is expected to have a compensatory effect on the projected yield changes of wheat (up to 17%) and maize (up to 12%). The largest contributors to overall yield change uncertainty were identified as the spread in crop models, followed by the spread in GCM. We concluded that by understanding the sources of uncertainty and employing techniques to quantify and manage them, it is possible to enhance the accuracy of model predictions and make more informed decisions in the face of climate change.

Keywords: climate impact, climate extremes, ensemble, HPC, uncertainty

DOI: https://doi.org/10.21203/rs.3.rs-3237885/v1

Rainfall variability and its seasonal events with associated risks for rainfed crop production in Southwest Ethiopia

Citation

Habte, A., Worku, W., Mamo, G., Ayalew, D., and Gayler, S. 2023. Rainfall variability and its seasonal events with associated risks for rainfed crop production in Southwest Ethiopia

Abstract

Risks associated with rainfall variability are among the most significant concerns for rainfed agricultural production in underdeveloped nations. Exploring the variability of rainfall and the risks connected with it is important for developing offsetting strategies. The purpose of this study was to investigate the variability of rainfall and its seasonal characteristics, as well as the associated risks in Southwest Ethiopia. The National Meteorological Agency of Ethiopia collected the daily rainfall and temperature data from 12 weather stations for the period from 1983 to 2016. ArcGIS was used to examine the regional distribution of rainfall variability at the temporal scale. The INSTAT+v3.37 software was used to assess the monthly and seasonal rainfall distribution, the start and end of the season, the length of the growing season, and the occurrence of dry spells. The coefficient of variation for annual, spring, summer, and autumn rainfall ranged from 17.79% to 29.93%, 21.23% to 41.56%, 36.38% to 122.00%, and 32.37% to 68.08%, respectively. The start and end dates of rain during the spring season varied from 65 to 129 and 122 to 176 days of the year, respectively. Rainfall variability was linked to risks such as late onset, early cessation, short and prolonged dry periods, and drought with a high frequency and moderate-to-severe intensity.

Keywords: dry spell, drought, end date of rainfall, onset of rainfall, variability

DOI: https://doi.org/10.1080/23311932.2023.2231693

The financial value of seasonal forecast-based cultivar choice: Assessing the evidence in the Central Rift Valley of Ethiopia

Citation

Kayamo, S.E., Troost, C., Yismaw, H., and Berger, T. 2023. The financial value of seasonal forecast-based cultivar choice: Assessing the evidence in the Central Rift Valley of Ethiopia

Abstract

Among many other options, seasonal weather forecasts and the use of cultivars that are better adapted to local climate and climate variability have been discussed as two potential measures to support farmers' adaptation to climatic variability and change. In this article, we evaluate the potential benefits of combining these two measures, specifically choosing specific crop varieties based on seasonal forecasts, with a focus on the Central Rift Valley in Ethiopia. We base our value of information analysis on the available records of field trial data for publicly released crop varieties. We find that experimental evidence must be extended and improved to provide reliable evidence of yield performance differences between crop varieties, which is an essential prerequisite for utilizing forecast information. Classification of cumulative seasonal rainfall based on the modified Rainfall Anomaly Index provides a sharper distinction than using the standard tercile-based approach employed in the Ethiopian seasonal forecast communication. Even with an optimistic interpretation of the evidence regarding exploitable yield differences, we find only modest benefits from seasonal forecasts at realistic forecast accuracy levels for the region. Given the empirical limitations in assembling long-run yield data, the presented results should be understood as a first approximation. Apart from sufficiently accurate forecasts, the success of forecast-based cultivar choice will depend on:

i. more reliable evidence on performance differences between crop varieties under different weather conditions, and

ii. changes in the current seed breeding and distribution system in developing countries, because the full potential of high-accuracy seasonal forecast information can only be tapped if forecast-matching cultivars are being made available to farmers in time.

Keywords: rainfall variability, seasonal forecast, climate change adaptation, agricultural decision-making, value of information

DOI: https://doi.org/10.1016/j.crm.2023.100541

Extreme climate shock and locust infestation impacts in Ethiopia: Farm-level agent-based simulation of adaptation and policy options

Citation

Ejeta, A.T. 2023. Extreme climate shock and locust infestation impacts in Ethiopia: Farm-level agent-based simulation of adaptation and policy options

Abstract

Extreme climate shocks have been a daunting problem for smallholder farmers in Ethiopia for a decade. In recent years, locust invasions in many parts of the country have become another significant challenge to the subsistence farming population, who already face dire livelihood situations. These two compounding shocks can lead to total crop failure at any stage of early crop development or crop growth. They are creating a massive economic upheaval in rainfed-dependent countries, particularly affecting the well-being of resource-poor subsistence farmers. To mitigate the impact of recurring shocks, especially climate-related risks, farmers have been implementing different risk management strategies. In addition to farmer-autonomous adaptation practices, the government has been supporting farmers' climate adaptation efforts by designing different policy interventions. In locust-hit areas, government and non-governmental organizations have designed and implemented different locust relief programs aimed at reducing associated welfare losses. Whether farmers can adapt to the effects of climate shocks or not through autonomous adaptation and/or with policy support is an empirical policy question. Moreover, as there are no studies on the impacts of locust and the evaluation of locust relief programs, the degree of locust livelihood devastation and the roles of locust relief policy interventions in minimizing the effects of locust shock are policy concerns. To address these important and key empirical questions, this thesis applied a farm-level agent-based simulation model. MPMAS, a modeling framework developed at the University of Hohenheim for agent-based simulations, was applied to capture inseparable production and consumption decisions of subsistence farming households in the Central Rift Valley of Ethiopia. The modeling framework employs a whole-farm mathematical programming modeling approach to represent the complex dynamics of farm household decisions, considering a set of constraints and their intricate relationships. This simulation model enables scenario-based policy analysis by comparing different climates, locust, and policy scenarios, which is hardly possible using statistical and other reduced forms of econometric models. Through establishing scenarios, the model helps to disentangle the pathways through which external shocks may affect the well-being of smallholder farmers. MPMAS has been extensively applied for policy simulations in different countries, including Ethiopia. This thesis extends previous MPMAS applications in Ethiopia by including new features for the Central Rift Valley (MPMAS_CRV). MPMAS_CRV was parameterized using the CIMMYT household survey, supplemented with CSA datasets and our own field research. Smallholder farmers' *ex-ante* considerations of risk management strategies for possible climate shocks are explicitly captured in MPMAS_CRV to assess their role in climate adaptation and welfare improvement. To enhance the adaptive capacity of farm households to recurring climate shocks, the effects of policy interventions, such as improved access to credit services and enhanced agricultural

technology, are quantified by establishing climate and policy scenarios. Similarly, the thesis quantified the impact of locust invasions on household welfare outcomes and their response to locust relief interventions, including food or cash transfers complemented with inputs and livestock provisions. Locust simulation is one of the novelties of this research, as it is the first study to explicitly capture the welfare effects of the desert locust and assess the roles of locust relief programs through the application of MPMAS. To enable the quantification of climate and locust shock effects and associated policy interventions, different simulation experiments were designed, encompassing different frequencies of climate and locust shocks and policy scenarios. The simulation experiments and analysis were conducted using the computational resources of *bwForCluster* within the *bwHPC* infrastructure in Baden-Württemberg, Germany. Before using MPMAS_CRV for policy simulations, its reliability was validated by comparing simulated values against observed survey values for land use, livestock holding, and crop sales. The validation results suggest that MPMAS_CRV can represent and reflect real-world conditions, making it a reliable tool for quantifying impact and conducting policy simulations. In addition to empirical validation, the thesis conducted a global uncertainty analysis to assess the robustness of the simulation results under different parameter variations and combinations, thereby minimizing the likelihood of erroneous policy formulations. Uncertainty analysis results indicate that the model converges rapidly after 50 repetitions, suggesting that these model repetitions are sufficient to encompass the model uncertainty space. In terms of extreme climate impacts and adaptations, the simulation results suggest that climate shocks have a negative impact on the welfare of agents, leading to temporary food shortages, a loss of discretionary income, and the depletion of livestock assets. The welfare losses are similar for both with and without *ex-ante* measure scenarios, which indicates that farm agents cannot adapt to extreme shocks by employing autonomous adaptations. After the shocks are over, the simulation results reveal that agents cannot recover income and livestock losses immediately, even when they consider *ex-ante* measures in the planning for possible risks. This suggests that for resource-poor farm agents, income and assets recovery takes a longer period after perturbation, which can lead to a long-term livelihood crisis and a poverty trap. However, according to the simulation results in this thesis, agents can recover from food shortages immediately after the shocks are over, as meeting minimum food requirements is an absolute priority for agents (which is also true for real-world subsistence smallholder farmers) over other competing goals. Credit and technology policy simulation analysis further depict that welfare losses are partly compensated compared to the situation without policies. Welfare losses of agents are better compensated when credit and technology are used jointly than when they are implemented separately. Similarly, technology policy intervention is more effective at compensating for welfare losses compared to credit policy. Although policy interventions have compensatory effects in minimizing losses, they cannot completely offset the negative effects of extreme climate shocks, even when implemented jointly. Disaggregation of simulation results by resource endowments suggests that agents with higher baseline incomes (without policy) and larger farm sizes appeared to be relatively less affected by shocks and benefited the most from policy interventions. Locust simulation results also suggest that locust shock leads to a livelihood crisis for agents, resulting in a slower recovery of income and livestock assets without the implementation of relief intervention

programs. Simulation of different locust relief policy interventions reveals that combined relief policy interventions appear to be more effective in compensating for welfare losses compared to individual relief interventions. When food or cash transfers are combined with inputs and assets, the welfare losses are considerably reduced compared to the individual policy interventions. When asset recuperation is combined with other relief programs, livestock losses are substantially reduced, indicating the importance of asset support in building a long-term asset base. Strengthening early warning systems by incorporating seasonal weather forecasting is of paramount importance in preventing the crisis of the desert locust plague.

URL: http://opus.uni-hohenheim.de/volltexte/2023/2154/

Ethiopia's wheat production pathways to self-sufficiency through land area expansion, irrigation advances, and yield gap closure

Citation

Senbeta, A.F., and Worku, W. 2023. Ethiopia's wheat production pathways to self-sufficiency through land area expansion, irrigation advances, and yield gap closure

Abstract

Ethiopia is the second-largest wheat producer in Africa. Although wheat production has been increasing steadily in the past decades, the demand for the crop has outstripped domestic supply. It forced the country to cover about 30% of the deficit through commercial imports and food aid. The utilization of wheat is rising at a rate of 9% annually, while production is increasing at 7.8%, indicating a continued widening gap between consumption and production. With a growing demand driven by a burgeoning population, increasing income, and a preference for wheat-based products, the country has a long journey ahead to achieve wheat self-sufficiency and conserve its scarce foreign currency reserves, which are currently spent on imports. The Ethiopian government is committed to achieving self-sufficiency through initiatives such as expanding wheat cultivation areas, developing irrigation systems, and closing yield gaps. In this review, we examined trends in wheat production and the impact of recent government initiatives on achieving wheat self-sufficiency. The review indicated that wheat production and productivity have increased in Ethiopia. However, the country's wheat self-sufficiency has declined from 99% in the 1960s to 70% at present. The future land area expansion in traditionally wheat-producing areas is limited, and wheat land suitability and yield potential are likely to decrease under climate change. Thus, the options of transforming the wheat sector while reducing greenhouse gas emissions include closing the yield gap through intensification on existing cropland and judicious temporal and spatial expansion of irrigated wheat areas. The yield gap closure requires higher and more efficient input supply and utilization, investments in modern technologies, as well as supportive agricultural policies. To improve the productivity of smallholder farmers and increase the intensity of production, investment in irrigation structures and facilities is required. Finally, we recommend further studies on yield gap analysis, the role of government initiatives, and wheat land suitability under current and future climate change scenarios at the local level.

Keywords: area expansion, climate change, Ethiopia, irrigation expansion, wheat self-sufficiency, yield gap closure

DOI: https://doi.org/10.1016/j.heliyon.2023.e20720

Irrigation as a crucial tool for the attainment of Sustainable Development Goals through hunger and poverty alleviation in Ethiopia: A review

Citation

Wendimu, A., Yoseph, T.Y., and Ayalew, T. 2023. Irrigation as a crucial tool for the attainment of sustainable development goals through hunger and poverty alleviation in Ethiopia: A review.

Abstract

Ethiopia has 74.3 million hectares of arable land and an irrigation potential of 3,088,395 hectares. Despite the country's vast irrigation potential, it has not reaped significant benefits. A huge percentage of Ethiopia's population is currently food insecure, and a very significant portion lives under the national poverty line. Studies have confirmed the role of irrigation in alleviating poverty and promoting food security. Irrigation plays a significant role in poverty reduction, especially in developing countries like Ethiopia, where agriculture is the backbone of the economy and a significant source of employment. Irrigation achieves this by boosting farmer incomes, improving crop productivity, providing more employment opportunities and better pay rates, and ultimately contributing to the national GDP. Irrigation also promotes food security by contributing to all the dimensions, including food availability, access to food, food utilization, and stability. Given the importance of irrigation in alleviating poverty and hunger, it is believed that the development of the sector significantly contributes to achieving the Sustainable Development Goals (SDGs). Hence, this article emphasizes the need to harness the country's vast irrigation potential and enhance the irrigation sector, enabling its population to escape the misery of hunger and poverty.

Keywords: irrigation, food security, poverty, Ethiopia, SDG

DOI: https://doi.org/10.20944/preprints202211.0468.v2

Ditching phosphatic fertilizers for phosphate-solubilizing biofertilizers: A step towards sustainable agriculture and environmental health

Citation

Wendimu, A., Yoseph, T., and Ayalew, T. 2023. Ditching phosphatic fertilizers for phosphate-solubilizing biofertilizers: A step towards sustainable agriculture and environmental health.

Abstract

Chemical phosphatic fertilizers are mainly produced from phosphate rocks, a natural reserve that is depleting rapidly. These chemical phosphatic fertilizers are polluting the environment at an alarming rate due to their injudicious application to farmlands. On the other hand, phosphate-solubilizing biofertilizers (PSBs) are often considered better alternatives to industrial phosphatic fertilizers in many ways. PSBs are microorganisms capable of solubilizing insoluble forms of phosphate into soluble plant-usable forms. This paper aims to discuss the impacts of phosphatic fertilizers and make the case for shifting to PSBs instead. Phosphatic fertilizers have numerous impacts on the environment (water bodies, land resources, and air), and micro- and macro-organisms, including humans. Chemical fertilizers are also more expensive, especially for farmers in developing countries. On the contrary, PSBs tend to be safer and more beneficial than their chemical counterparts, as they are environmentally friendly and are cheaper options for obtaining plant-usable phosphorus. PSBs also play other beneficial roles, including the production of phytohormones and the secretion of anti-phytopathogenic metabolites. The phytohormones enhance plant growth, and the metabolites confer immunity to crops against phytopathogens. Hence, it is vital to replace chemical phosphatic fertilizers with PSB inoculants both to prevent the irreversible impacts of chemical fertilizers and to take advantage of the numerous benefits of PSBs. Moreover, it does not seem that there is an alternative, given that the global phosphate reserve is depleting, and the environmental impact of fertilizers is worsening over time.

Keywords: PSB, environment, fertilizer, phosphate

DOI: https://doi.org/10.3390/su15021713

Climate change impact on wheat and maize growth in Ethiopia: A multi-model uncertainty analysis

Citation

Rettie, F.M., Gayler, S., KD Weber, T., Tesfaye, K., and Streck, T. 2022. Climate change impact on wheat and maize growth in Ethiopia: A multi-model uncertainty analysis

Abstract

Ethiopia's economy is primarily driven by agriculture, which is predominantly rainfed and subsistence based. Climate change is expected to have an adverse impact, particularly on crop production. Previous studies have shown large discrepancies in the magnitude and sometimes in the direction of the impact on crop production. We assessed the impact of climate change on the growth and yield of maize and wheat in Ethiopia using a multi-crop model ensemble. The multi-model ensemble (n = 48) was set up using the agroecosystem modeling framework Expert N. The framework is modular, facilitating the combination of different submodels for plant growth and soil processes. The multi-model ensemble was driven by climate change projections representing the mid-century (2021–2050) from ten contrasting climate models downscaled to finer resolution.

The contributions of different sources of uncertainty in crop yield prediction were quantified. The sensitivity of crop yield to elevated CO_2, increased temperature, changes in precipitation, and N fertilizer was also assessed. Our results indicate that grain yields were very sensitive to changes in [CO_2], temperature, and N fertilizer amounts, where the responses were higher for wheat than maize. The response to the change in precipitation was weak, which we attribute to the high water-holding capacity of the soils, due to their high organic carbon content at the study sites. This may provide sufficient buffering capacity for extended time periods with low amounts of precipitation. Under the changing climate, wheat productivity will be a major challenge, with a 36% to 40% reduction in grain yield by 2050, while the impact on maize was modest. A significant portion of the uncertainty in the projected impact can be attributed to differences in crop growth models. A considerable fraction of the uncertainty can also be attributed to the different soil water dynamics modeling approaches within the model ensemble, which are often overlooked. Uncertainties varied among the studied crop species and cultivars as well. The study highlights the significant impacts of climate change on wheat yields in Ethiopia, where differences in crop growth models contribute substantially to the uncertainties.

Keywords: climate change, crop model, Expert-N, multi-model, uncertainty

DOI: https://doi.org/10.1371/journal.pone.0262951

Effects of elevated atmospheric CO_2 and its interaction with temperature and nitrogen on yield of barley (*Hordeum vulgare* L.): A meta-analysis

Citation

Gardi, M.W., Haussmann, B.I., Malik, W.A., and Högy, P. 2022. Effects of elevated atmospheric CO_2 and its interaction with temperature and nitrogen on yield of barley (*Hordeum vulgare* L.): A meta-analysis

Abstract

The general aim of this meta-analysis is to synthesize and summarize the mean response of barley yield variables to elevated CO_2 (eCO_2) and how temperature and nitrogen (N) affect the CO_2-induced yield responses of barley. A meta-analysis procedure was used to analyze five yield variables of barley extracted from 22 studies to determine the effect size and the magnitude concerning eCO_2 and its interaction with temperature and N. CO_2 enrichment increased above-ground biomass (23.8%), grain number (24.8%), and grain yield (27.4%). The magnitude of the responses to eCO_2 was influenced by genotype, temperature, nitrogen, and the methods of CO_2 exposure. Genotype "*Anakin*" showed the highest CO_2 response of above-ground biomass (47.1%), while "*Bambina*" had the highest grain number (58.4%). Grain yield response was observed to be higher for genotypes "*Alexis*" (38.1%) and "*Atem*" (33.7%) under elevated CO_2 (eCO_2). The increase in above-ground biomass and grain yield was higher when plants were grown under eCO_2 in combination with higher nitrogen (N) levels (151 kg–200 kg ha^{-1}). The interaction between eCO_2 and three different temperature levels was analyzed to identify the impacts on barley yield components. The results revealed that the CO_2-induced increase in grain number and grain yield was higher in combination with a temperature level of 21 °C–25 °C compared to lower levels (< 15 °C and 16 °C–20 °C). The response of barley yield to eCO_2 was higher in growth chambers than in other CO_2 exposure methods. Moreover, a higher response of above-ground biomass and grain yield to eCO_2 was observed for pot-grown plants compared to field-grown plants.

Keywords: climate change, systematic review, global change, *Hordeum vulgare* L., yield variables

DOI: https://doi.org/10.1007/s11104-022-05386-5

Simulating the effect of climate change on barley yield in Ethiopia with the DSSAT-CERES-barley model

Citation

Gardi, M.W., Memic, E., Zewdu, E., and Graeff-Hönninger, S. 2022. Simulating the effect of climate change on barley yield in Ethiopia with the DSSAT-CERES-Barley model

Abstract

Climate change is expected to have a major effect on crop production in sub-Saharan Africa. Crop models can help guide crop management under future climate conditions. The objective of the study was to investigate the possible effects of climate change on Ethiopian barley *(Hordeum vulgare* L.) production using the Decision Support System for Agrotechnology Transfer (DSSAT)-Crop Environment Resource Synthesis (CERES)-Barley model. The study included field data from two barley cultivars (Traveller and EH-1493) and four climate study areas in Ethiopia, spanning five years. Climate change scenarios were established over 60 years using representative concentration pathways (RCPs) and five global climate models (GCMs), specifically RCP4.5 and RCP8.5. The model results indicated that the prediction of days to anthesis and maturity, as well as final grain yield, was highly accurate for cultivar Traveller with normalized RMSE (nRMSE) of 2%, 1%, and 12%, respectively, and for cultivar EH-1493 with nRMSE of 2%, 4%, and 11%. A consistent increase in average temperature up to 5 °C and a mixed pattern of rainfall (61 to +86%) were projected. Yield simulations indicated a potential yield reduction up to 98% for cultivar Traveller and 63% for cultivar EH-1493 in the future. Within a sensitivity analysis, different sowing dates, sowing densities, and fertilizer rates were examined as potential adaptation strategies to climate change. Early sowing, with a 25% increase in sowing density, could mitigate the negative effects of climate change and a fertilizer rate of 50% higher than recommended. Overall, the results demonstrated the CERES-Barley model's ability to assess the effects of climate change and adaptation options on rainfed barley production in Ethiopia.

Keywords: adaptation, barley, CERES-Barley, climate change, impact

DOI: https://doi.org/10.1002/agj2.21005

Climate regionalization using objective multivariate clustering methods and characterization of climatic regions in Ethiopia

Citation

Ware, M.B., Mori, P., Warrach-Sagi, K., Jury, M., Schwitalla, T., Beyene, K.H., and Wulfmeyer, V. 2022. Climate regionalization using objective multivariate clustering methods and characterization of climatic regions in Ethiopia

Abstract

Objective climate regionalization is essential in environmental and climate studies, particularly over regions with complex terrain and meteorological conditions. The study aimed to define and characterize homogenous climatic regions over Ethiopia using a combination of principal component analysis (PCA) and K-means clustering, as well as PCA and Ward's clustering. We utilized Climate Hazards Group Infrared Precipitation with Stations (~6km resolution) and TerraClimate (~4km resolution) data, collected between 1985 and 2018. Additionally, data from weather stations provided by the National Meteorology Agency of Ethiopia were applied to assess seasonal and annual precipitation and temperature trends across climatic regions in the 1985–2018 period. Homogeneous climatic regions were defined by applying PCA–K-means and PCA–Ward clustering methods on a matrix derived from precipitation and a combination of precipitation, maximum, and minimum temperatures. The trends in seasonal rainfall and maximum and minimum temperatures over the respective regions were computed by fitting a linear regression model to each grid cell. Significant differences in the trends were assessed using the Mann-Kendall test. The results show that it is sufficient and reasonable to define four homogeneous climatic regions. These homogeneous climatic regions have distinct annual cycles, seasonal rainfall and temperature trends, and annual rainfall anomalies. The heterogeneity of the climatic regions between the two-time windows (1985–2001 and 2002–2018) is negligible, demonstrating the robustness of the regionalization methods. The seasonal rainfall during the short rains has increased by 50 mm/decade in the southwestern region. The mean annual and seasonal temperatures have increased by 0.3 to 0.66 °C per decade in all climatic regions. The climate regions defined in the present study are reliable. They can be utilized in various studies at both national and regional levels to evaluate seasonal forecasts and downscale global forecasts, thereby facilitating the development of agricultural plans and strategies that enhance food security.

Keywords: K-means clustering, ward's clustering, Ethiopia, climatic regions, objective regionalization

DOI: https://doi.org/10.1127/metz/2022/1093

Cowpea (*Vigna unguiculata* L. Walp.): A choice crop for sustainability during the climate change periods

Citation

Ayalew, T., and Yoseph, T. 2022. Cowpea (*Vigna unguiculata* L. Walp.): A choice crop for sustainability during the climate change periods

Abstract

Climate change is significantly affecting food security and environmental health. The effect is more severe for countries with low adaptive capacity in the developing world. Legumes are among the potential solutions for agriculture's sustainability during climate change times, as they minimize the use of mineral fertilizers because of symbiotic nitrogen (N) nutrition. Cowpea is a multipurpose legume crop with combined agronomic, environmental, nutritional, and economic advantages. Cowpea provides dietary protein and serves as a source of income for millions of rural poor in developing countries. Cowpea also enhances soil fertility by contributing a significant amount of N through N_2 fixation.

Nevertheless, cowpea productivity remains low in Ethiopia, and there is a lack of awareness regarding the multifunctional roles the crop can play, its response to climate change, and the use of bioinoculants. Therefore, this review aimed to assess the agrosymbiotic performance, utilization, and climate change response capacity of the crop to exploit its potential for sustainability. The review results revealed that cowpea performs better than most legumes grown in the tropics, achieving acceptable yield performance with limited rainfall of up to 450 mm per year and heat stress. Moreover, elevated CO_2 is reported to enhance N_2 fixation in cowpea, resulting in improved photosynthesis and increased seed yield. On the other hand, high temperature and elevated ultraviolet radiation reduced the performance of the cowpea crop as these factors inhibit symbiosis. In Ethiopia, the mature seeds of cowpea, immature pods, and leaves are used for food in the country's lowland areas. Approximately 66.5% of Ethiopia's arable land is suitable for cowpea production. However, the average yield is limited to 400 kg ha^{-1}, with annual production and land coverage of 55,600 tons and 69,500 ha, respectively. Overall, this review confirmed the excellent nature of cowpea in terms of its response to climate change and the diversity of services the crop can offer. According to the review, Ethiopia has the potential to increase cowpea productivity, given its suitable land and agroecology. Therefore, the introduction of improved varieties and agronomic practices, including bioinoculants, should be a key focus to increase cowpea yield and benefit from the manifold roles the crop can play.

Keywords: biological nitrogen fixation, climate, elevated CO_2, legumes, photosynthesis, seed yield, temperature

DOI: https://doi.org/10.7324/JABB.2022.100320

Optimizing maize–bean cropping systems for sustainable intensification in southern Ethiopia

Citation

Yimer, T., Abera, G., Beyene, S., and Rasche, F. 2022. Optimizing maize–bean cropping systems for sustainable intensification in southern Ethiopia

Abstract

Declining productivity and the scarcity of cultivable land in smallholder systems necessitate exploring sustainable intensification options to increase productivity. Field experiments were conducted at five sites (Sites 1–5) of the Sidama region, southern Ethiopia, in 2018 and 2019 to determine the effects of cropping systems on maize (*Zea mays* L.) and common bean (*Phaseolus vulgaris* L.) productivity. The intercropping of common bean with maize at varying planting times (simultaneous and relay) and the number (frequency) of legume intercropping (once or twice) per growing season were compared with monocultures of the components in a randomized complete block design with four replications. The cropping system affected the agronomic parameters (pod number plant^{-1} and 100-seed weight) of common bean more significantly than maize. Specifically, the results revealed that cropping systems affected both maize and bean yields, although the magnitude of the effect varied with sites. The highest maize yield was recorded in fertilized monoculture maize at Sites 1, 2, and 5, and in relay and sequential bean intercropping at Sites 3 and 4, respectively. Moreover, the highest bean yields were obtained in double common bean monoculture, whereas the lowest yields were recorded in relay intercropping. The total land equivalent ratio (LER) ranged from 1.2 to 1.8, and the partial LER of maize was higher than that of the common bean. Sequential intercropping (Sites 1, 2, and 5) and relay intercropping (Sites 3 and 4) were economically more beneficial than the other cropping systems. Therefore, farmers could benefit more from maize–bean intercropping systems than monocultures in areas where maize is a staple crop.

Keywords: economic benefit, intercropping, land equivalent ratio (LER), smallholder systems, system productivity

DOI: https://doi.org/10.1002/agj2.21143

Pretreatment of the leaves of Ethiopian cassava (*Manihot esculenta* Crantz) varieties: Effect of blanching on the quality of dried cassava leaves

Citation

Ayele, H.H., Latif, S., and Müller, J. 2022. Pretreatment of the leaves of Ethiopian cassava (*Manihot esculenta* Crantz) varieties: Effect of blanching on the quality of dried cassava leaves

Abstract

This work aimed to study the effect of blanching and drying on the quality of four Ethiopian cassava varieties (Chichu, Hawassa-4, Quelle, and Kello). Cassava leaves were subjected to blanching at 100 °C in plain water, 0.2% $NaHCO_3$, and 0.4% $NaHCO_3$ for five minutes. Cassava leaves without blanching were considered as a control. The drying temperature was set at 60 °C with a constant air velocity of 0.14 ms^{-1}. A high reduction in vitamin C (95.6% in Chichu, 95.0% in Hawassa-4, 94.9% in Quelle, and 94.4% in Kello) was noticed in leaves blanched in the 0.4% $NaHCO_3$ solution. After blanching, the reduction in the ash content was higher for those blanched in plain water. The crude fiber and protein content were improved by blanching. Blanching in clear water was more effective among the different solutions in reducing the cyanide content in the leaves of Kello, Quelle, and Chichu by 51, 33, and 60%, respectively. While for Hawassa-4, the reduction was higher (47%) with the 0.2% $NaHCO_3$ solution. After blanching, the h values decreased, while a*, b*, and c* increased. Plain water blanching resulted in a better nutritional quality, while Hawassa-4 exhibited the best nutritional value among the four varieties.

Keywords: cassava leaves, blanching, $NaHCO_3$, nutrient, cyanide, vitamin C

DOI: https://doi.org/10.3390/app122111231

Carbon assimilation and water-use efficiency in cowpea varieties inoculated with *Bradyrhizobium*, measured using ^{13}C natural abundance

Citation

Ayalew, T., Yoseph, T., and Cadisch, G. 2022. Carbon assimilation and water-use efficiency in cowpea varieties inoculated with Bradyrhizobium, measured using ^{13}C natural abundance

Abstract

Moisture stress is one of the most important constraints for crop production in arid regions. Cowpea is a vital food legume that has been cultivated in tropical and subtropical regions where water is scarce. Rhizobia inoculation confers resistance to water stress in legumes. Two-year field experiments were conducted to assess the carbon assimilation and water use efficiencies of inoculated cowpea varieties at three sites. The treatments consist of four varieties and three levels of *Bradyrhizobium* inoculation arranged in a factorial randomized complete block design with four replications. The nitrogen (%N) and carbon (%C) concentrations in plant shoots were determined directly through the mass spectrometric analysis. The results revealed considerable variation for shoot percentage N and percentage C, shoot growth, and $\delta^{13}C$ among the varieties. Similarly, *Bradyrhizobium* significantly affected plant growth, percentage C, and N contents, C/N ratio, and carbon isotope discrimination in the shoot. For instance, C and N contents and the C/N ratio increased by 28%, 24%, and 31%, respectively, due to *Bradyrhizobium* inoculation. In general, these results indicate that physiological performances, such as carbon assimilation and water use efficiency of the crop, could be significantly improved when effective *Bradyrhizobium* strains and the best-performing varieties are selected.

Keywords: carbon concentration, cowpea, inoculation, nitrogen concentration, and $\delta^{13}C$ (‰)

DOI: https://doi.org/10.1080/17429145.2022.2075943

Elevated UV-B radiation depressed biomass yield and symbiotic N_2-fixation in *Bradyrhizobium* inoculated cowpea varieties

Citation

Ayalew, T., Yoseph, T., and Cadisch, G. 2022. Elevated UV-B radiation depressed biomass yield and symbiotic N_2-fixation in *Bradyrhizobium* inoculated cowpea varieties

Abstract

The Rhizobium-legume symbiosis plays an important role in enhancing soil fertility and crop productivity, particularly in inherently poor soils in developing countries. However, nodulation and symbiotic nitrogen fixation in tropical legumes may be reduced due to climate change-driven increases in ultraviolet-B (UV-B) radiation. Hence, a greenhouse experiment was conducted to evaluate the effect of UV-B radiation on two cowpea varieties inoculated with a *Bradyrhizobium* strain. The treatments studied consisted of two cowpea varieties (Keti (IT99K-1122) and TVU), two levels of inoculation (control and inoculated with *Bradyrhizobium* strain CP-24), and two UV-B radiation levels (ambient and 0.4 W m^{-2} supplement) laid out in a completely randomized design with three replications. The ^{15}N natural abundance technique was used to estimate the symbiotic N_2 Fixation. Analysis of variance revealed that treatments had a significant effect on the performance of cowpea varieties, and varieties responded differently to elevated UV-B radiation. Of the two varieties, Keti produced more nodules and nodule dry weight; however, the TVU variety excelled in shoot biomass, shoot N content, and Fixed-N. Inoculation markedly increased shoot biomass, nodule dry weight, shoot N content, and amount of N fixed. On the other hand, the supplemented UV-B radiation caused a significant reduction in nodule number (55%), nodule dry weight (74%), shoot biomass (22%), shoot N content (18%), and amount of Fixed-N (19%) compared to the plants grown under ambient UV-B conditions. These findings, therefore, indicate the need to identify improved UV-B-resistant varieties and inoculants with the capacity to nullify UV-B effects, thereby minimizing the current and projected effects of UV-B radiation on the symbiotic nitrogen contribution of nodulating legumes during climate change.

Keywords: cowpea, nitrogen content, N-fixed, symbiosis, ultraviolet-B radiation, δ15 N

DOI: https://doi.org/10.1007/s13199-022-00868-7

Leaf growth, gas exchange, and assimilation performance of cowpea varieties in response to *Bradyrhizobium* inoculation

Citation

Ayalew, T., Yoseph, T., Högy, P., and Cadisch, G. 2022. Leaf growth, gas exchange, and assimilation performance of cowpea varieties in response to *Bradyrhizobium* inoculation

Abstract

Supplying nitrogen to crops through selecting high N-fixing legumes and effective inoculants is one of the key strategies to improve crop productivity. However, studies related to the effect of *Bradyrhizobial* inoculation on leaf growth, its functioning in relation to photosynthesis, and transpiration efficiency (WUE) of cowpea [*Vigna unguiculata* (L.) Walp] varieties in the tropics were inadequate. A two-year field experiment was conducted at three sites to evaluate the effect of inoculation on leaf growth, gas exchanges, and photosynthetic efficiency of cowpea varieties. The study treatments consisted of four varieties: Keti (IT99K-1122), TVU, black eye bean, and White Wonderer Trailing, and three levels of inoculation (non-inoculated or inoculated with *Bradyrhizobium* strains CP-24 or CP-37). Gas exchange was measured on live plants at 67–77 days after sowing, between 8:00 a.m. to 11:00 a.m. and 2:00 p.m. to 4:00 p.m. Leaf growth parameters (leaf number and leaf area) were measured by destructive sampling, and the yield data were determined by harvesting plants in the three central rows at physiological maturity. Variety TVU performed best in terms of leaf number, photosynthesis rate, and WUE, while black eye bean revealed superior performances for leaf area, leaf area index, and stomatal conductance compared with the other two varieties. The effect of inoculation was significant, with advantages of 14.0%, 23.8%, 13.7%, and 11.0% in leaf area, leaf area index, net photosynthesis, and WUE, respectively. Moreover, the performance of cowpea of the 2018 cropping season showed a relative advantage over 2019 in terms of leaf number, leaf area, leaf area index, net photosynthesis, and stomatal conductance. Therefore, inoculating cowpea varieties with an effective *Bradyrhizobium* strain can be a viable alternative to enhance growth, gas exchange, photosynthetic efficiency, and grain yield.

Keywords: internal CO_2 concentration, leaf area index, stomatal conductance, Net photosynthesis, transpiration efficiency

DOI: https://doi.org/10.1016/j.heliyon.2022.e08746

UV-B radiation-induced photosynthetic depression in cowpea [*Vigna unguiculata* (L.) Walp] nullified through inoculation of *Bradyrhizobium* strain

Citation

Ayalew, T., Yoseph, T., and Gobena, A. 2022. UV-B radiation-induced photosynthetic depression in cowpea [*Vigna unguiculata* (L.) Walp] nullified through inoculation of *Bradyrhizobium* strain

Abstract

During the era of climate change, an increase in ultraviolet-B (UV-B) radiation (280-315 nm) affects the growth and physiology of crop plants. Cowpea may already be experiencing the effects of the increasing doses of UV-B radiation since the crop mostly grows in the tropical and subtropical regions, where maximum solar UV-B radiation reaches the earth's surface. Knowledge of the varietal response and the extent of the UV-B effect under inoculation is important in identifying a suitable variety and implementing agronomic management strategies to current and future changes in UV-B radiation. A pot experiment was conducted to evaluate the sensitivity of inoculated cowpea varieties to UV-B radiation. Two cowpea varieties and the *Bradyrhizobium* strain CP-24 tested in the preceding pot and field experiments were combined with two biologically effective UV-B radiation levels (ambient and 0.4 W m^{-2} supplement). The UV-B radiation of 0.4 W m^{-2} was supplemented from nine days after emergence up to fifty-five days of the crop growth stage. Significant varietal differences were observed for the UV-B responsiveness of twelve plant attributes measured. The magnitude of the sensitivity to UV-B radiation also varied among cowpea varieties. Plants grown under elevated UV-B radiation had much shorter and lower shoot dry weight than those grown under ambient UV-B radiation. The physiological gas exchange parameters exhibited a significantly negative response to elevated UV-B radiation, with reductions of 58%, 65%, 31%, and 8% in stomatal conductance (gs), net photosynthesis (Pn), stomatal number, and maximal photosystem II efficiency (Fv/Fm), respectively.

Furthermore, comparing the inoculated plants under elevated UV-B radiation with those inoculated under ambient UV-B radiation, reductions of 42%, 42%, and 79% were observed in leaf area, leaf area index, and net photosynthesis, respectively, indicating a negative effect of UV-B radiation on inoculant performance. It was also observed that inoculating *Bradyrhizobium* strain CP-24 has the potential to nullify UV-B radiation-induced photosynthetic depression. The negative effects of UV-B radiation, as demonstrated by many of the measured parameters, emphasize the need to select or develop varieties and bio-fertilizers that can withstand the potential effects of current and projected UV-B radiation.

Keywords: chlorophyll fluorescence, gas exchange, inoculants, leaf growth, photosynthesis rate, stomata

DOI: https://ssrn.com/abstract=4094664

Diacetoxyscirpenol, a *Fusarium* exometabolite, efficiently prevents the incidence of the parasitic weed *Striga hermonthica*

Citation

Anteyi, W.O., Klaiber, I., and Rasche, F. 2022. Diacetoxyscirpenol, a *Fusarium* exometabolite, efficiently prevents the incidence of the parasitic weed *Striga hermonthica*

Abstract

Certain *Fusarium* exometabolites have been reported to inhibit seed germination of the cereal-parasitizing witchweed, *Striga hermonthica*, *in vitro*. However, it is unknown if these exometabolites will consistently prevent *S. hermonthica* incidence in *planta*. The study screened a selection of known, highly phytotoxic *Fusarium* exometabolites to identify the most potent and efficient candidate (i.e., having the greatest effect at the lowest concentration) to hinder *S. hermonthica* seed germination *in vitro* and incidence *in planta*, without affecting the host crop development and yield completely. *In vitro* germination assays of the tested *Fusarium* exometabolites (i.e., 1,4-naphthoquinone, equisetin, fusaric acid, hymeglusin, neosolaniol (Neo), T-2 toxin (T-2), and diacetoxyscirpenol (DAS)) as pre-*Striga* seed conditioning treatments at 1, 5, 10, 20, 50, and 100 µM, revealed that only DAS, out of all tested exometabolites, completely inhibited *S. hermonthica* seed germination at each concentration. T-2 and Neo followed at concentrations of 10 to 20 µM, respectively. The remaining exometabolites reduced *S. hermonthica* seed germination from 20 µM ($P < 0.0001$). In *planta* assessment (in a *S. hermonthica*-sorghum parasitic system) of the exometabolites at 20 µM showed that, although none of the tested exometabolites affected sorghum above-ground dry biomass ($P > 0.05$), only DAS completely prevented *S. hermonthica* incidence. Following a 14-d incubation of DAS in the planting soil substrate, bacterial 16S ribosomal RNA (rRNA) and fungal 18S rRNA gene copy numbers in the soil microbial community were enhanced, which coincided with the complete degradation of DAS in the substrate. Metabolic foot printing revealed that the *S. hermonthica* mycoherbicidal agent, *Fusarium oxysporum* f. sp. *strigae* (isolates Foxy-2, FK3), did not produce DAS; a discovery that corresponded with underexpression of key genes (*Tri5*, *Tri4*) necessary for *Fusarium* trichothecene biosynthesis ($P < 0.0001$). Among the tested *Fusarium* exometabolites, DAS exhibited the most promising herbicidal potential against *S. hermonthica*. Thus, it could serve as a new biocontrol agent for efficient management of *S. hermonthica*. Further examination of DAS's specific mode of action against the target weed *S. hermonthica* at low concentrations (≤ 20 µM), as opposed to non-target soil organisms, is required.

Keywords: *Striga hermonthica*, *Fusarium oxysporum* f. sp. *strigae*, *Fusarium* exometabolites, diacetoxyscirpenol, biopesticides, targeted metabolomics, metabolic footprinting, trichothecene gene expression

DOI: https://doi.org/10.1186/s12870-022-03471-6

Partial substitution of concentrate mix with dried *Leucaena leucocephala* leaf reduced *in vitro* methane production in rams without affecting the nutrient intake and performance traits

Citation

Tadesse, A., Melesse, A., and Rodehutscord, M. 2022. Partial substitution of concentrate mix with dried *Leucaena leucocephala* leaf reduced *in vitro* methane production in rams without affecting the nutrient intake and performance traits

Abstract

Through *in vitro* studies, dried *Leucaena leucocephala* leaf (DLL) was identified as a potential candidate in mitigating enteric methane (CH_4) emissions. Nevertheless, its suitability as a feed for sheep in Ethiopia has not been determined. Therefore, this study aimed to assess the suitability of replacing the concentrate mix (CM) with DLL in terms of voluntary intake, growth performance in rams, and *in vitro* CH_4 production. To achieve this, thirty yearling rams were first stratified according to their initial body weight similarities, and then individuals from each stratum were randomly assigned to five treatment diets, with six rams in each group. The control diet contained CM with 346 g/head/d (T1), and treatment diets replacing the CM in the control diet with DLL at a rate of 5% (T2), 10% (T3), 15% (T4) and 20% (T5) with the corresponding CM to DLL mixture ratio of 346:0, 329:17, 311:35, 294:52 and 277:69 g/head/day. Grass hay was provided *ad libitum* to all rams. Data were collected on feed intake and body weight. Methane (CH_4) production was determined along with 24-h *in vitro* gas production (GP). Digestible organic matter (DOM) and metabolizable energy (ME) were estimated from 24h GP. The results indicated that the contents of ash, crude protein (CP), neutral detergent fiber (NDFom), acid detergent fiber (ADFom), and acid detergent lignin were higher in DLL than in the control diet, while it contained the lowest EE value. DLL had the highest Ca and K values as compared to the control diet. The feed intake, live weight, and weight gain did not differ ($P > 0.05$) among rams supplemented with various levels of DLL. The total intake of CP increased across the treatment diets and was significantly higher for T3, T4, and T5 than for T1 and T2. None of the supplementation levels of *L. leucocephala* affected the total intake of DM, NDFom, and ADFom. There was a linear reduction ($p < 0.05$) in *in vitro* CH_4 production as the levels of DLL in the diet increased. It was lowest in the T4 and T5 diets, being significantly different from those of T1 and T2. The T5 diet showed the lowest values and differed ($p < 0.05$) from those of T1, T2, and T3. The ME and DOM values were higher ($p < 0.05$) in T1 and T2 diets than those of T4 and T5. No difference in DOM values and ME was observed between T1, T2, and T3 diets, as well as between T4 and T5 diets. The current findings suggest that conventional CM could be replaced with DLL up to 20% as an alternative protein source in ruminant nutrition in tropical and subtropical regions. Conclusion. The replacement of CM with DLL significantly reduced the *in vitro* CH_4 production across treatment diets without affecting the voluntary intake and growth performance parameters in rams.

Keywords: live weight, nutrient intake, concentrate mix, enteric methane, *Leucaena leucocephala*, leaf, rams.

DOI: https://doi.org/10.56369/tsaes.4060

Optimization of nutritional and functional qualities of local complementary foods of southern Ethiopia using a customized mixture design

Citation

Ayele, D.A., Teferra, T.F., Frank, J., and Gebremedhin, S. 2022. Optimization of nutritional and functional qualities of local complementary foods of southern Ethiopia using a customized mixture design

Abstract

Commercially produced complementary foods are inaccessible to rural households in Ethiopia. This study aimed to optimize the nutritional and functional properties of local complementary foods using flours of the following locally available crops: maize, red kidney bean, *kocho*, and pumpkin fruit. Ten formulations were generated using a customized mixture design. A five-point hedonic scale was used to determine organoleptic properties, and standard methods were employed to analyze nutritional composition and functional properties. The flours were mixed at a range of 20–30% for *kocho*, 10–25% for pumpkin fruit, 10–40% for red kidney beans, and 15–30% for maize. Optimal nutritional and functional properties were achieved using a blend of 33.5% *kocho*, 22.5% maize, 17.5% pumpkin, and 26.5% red kidney beans. Optimal values for functional properties were 0.86 g/ml, 5.94 ml/g, 4.14 ml/g, 2.96 g/g, 5.0 ml/g, and 1225.3 cP for bulk density, water absorption capacity, oil absorption capacity, swelling capacity, swelling index, and viscosity, respectively. All formulations were within acceptable limits, with scores ranging from 3.00 to 4.32 on a scale of five. The inclusion of 25% pumpkin fruit flour and other ingredients between 20% and 30% increased the provitamin A (carotenoid) and vitamin E contents of the composite flours. Aside from optimization, a higher concentration of limiting amino acids was achieved with 40% kidney beans and 15–25% of the other ingredients. The mineral content improved with the increase of pumpkin, kidney beans, and *kocho*. In conclusion, the nutrient quality, energy density, and functional quality of complementary foods can be optimized at a low cost using local ingredients.

Keywords: child nutrition, fortified food, infant, minerals, product optimization, vitamins

DOI: https://doi.org/10.1002/fsn3.2663

Spatial variability and temporal trends of climate change in Southwest Ethiopia: Association with farmers' perception and their adaptation strategies

Citation

Habte, A., Mamo, G., Worku, W., Ayalew, D., and Gayler, S. 2021. Spatial variability and temporal trends of climate change in Southwest Ethiopia: association with farmers' perception and their adaptation strategies

Abstract

The impact of climate change is a global threat, and its effect is more pronounced in developing countries. It is vital to link physical data analysis with endogenous knowledge and practices of farmers to strengthen their adaptive capacity. This study was conducted to explore the spatial variability and temporal trends of temperature and rainfall in relation to farmers' perceptions and their adaptation strategies in Southwest Ethiopia. The National Meteorological Agency of Ethiopia collected daily rainfall and temperature data from 12 weather stations for the period 1983–2016. Farmers' perceptions of climate change and its impact, as well as their adaptation strategies, were assessed through a survey. Spatial variability and temporal trends of rainfall and temperature were analyzed using ArcGIS and R software. Sen's slope estimator and Mann–Kendall trend tests were used to detect the magnitude and statistical significance of changes in rainfall and temperature. Spatial analysis of rainfall showed high variability over the region. There were no consistent and significant temporal trends in annual and seasonal rainfall in the area. Significant and upward trends of annual maximum and minimum temperatures were reported for all stations. Accordingly, annual maximum and minimum temperatures were increased by 0.71 °C and 0.65 °C, respectively, over the period 1983 to 2016. Farmers had a good awareness of climate change and its impact. Adaptation strategies used by farmers included soil and water conservation practices (66.21%), crop diversification (62.16%), modifying planting date (42.56%), agroforestry practices (35.13%), use of drought-tolerant variety (33.95%), use of early maturing crop (27.03%), and livelihood diversification (25.42%). As a small number of farmers have adopted most of these adaptation strategies, further efforts are needed to identify the factors limiting the adoption. Furthermore, additional planned strategies and supports that widen available options at the farmers' disposal should be introduced to strengthen their adaptive capacity.

Keywords: adoption, annual trends, rainfall, seasonal trends, temperature

DOI: https://doi.org/10.1155/2021/3863530

Impacts of carbon dioxide enrichment on landrace and released Ethiopian barley (*Hordeum vulgare* L.) cultivars

Citation

Gardi, M.W., Malik, W.A., and Haussmann, B.I. 2021. Impacts of carbon dioxide enrichment on landrace and released Ethiopian barley (*Hordeum vulgare* L.) cultivars

Abstract

Barley (*Hordeum vulgare* L.) is an important food security crop due to its high tolerance to stress. This study explored the effects of CO_2 enrichment (eCO_2) on the growth, yield, and water-use efficiency of Ethiopian barley cultivars (15 landraces, 15 released). Cultivars were grown under two levels of CO_2 concentration (400 ppm and 550 ppm) in climate chambers, with each level replicated three times. A significant positive effect of eCO_2 was observed on plant height by 9.5% and 6.7%, vegetative biomass by 7.6% and 9.4%, and grain yield by 34.1% and 40.6% in landraces and released cultivars, respectively. The observed increase in grain yield primarily resulted from the significant positive effect of eCO_2 on the number of grains per plant. The water-use efficiency of vegetative biomass and grain yield increased significantly by 7.9% and 33.3% in landraces, with improvement of 9.5% and 42.9% in released cultivars, respectively. Pearson correlation analysis revealed positive relationships between grain yield and grain number (r = 0.95), harvest index (r = 0.86), and ear biomass (r = 0.85). The response of barley to eCO_2 was cultivar dependent, i.e., the highest grain yield response to eCO_2 was observed for Lan_15 (122.3%) and Rel_10 (140.2%). However, Lan_13, Lan_14, and Rel_3 showed reduced grain yield by 16%, 25%, and 42%, respectively, in response to eCO_2 enrichment. While the released cultivars benefited more from higher levels of CO_2 in relative terms, some landraces displayed better actual values. Under future climate conditions characterized by higher CO_2 concentrations, grain yield production could benefit from the promotion of landrace and released cultivars with higher grain numbers and higher levels of water-use efficiency of the grain. The superior cultivars that were identified in the present study represent valuable genetic resources for future barley breeding.

Keywords: barley, biomass, CO_2 enrichment, *Hordeum vulgare* L., water-use efficiency, yield

DOI: https://doi.org/10.3390/plants10122691

Assessment of the production and importance of cowpea [*Vigna unguiculata* (L.) Walp]: Cases from selected districts of southern Ethiopia

Citation

Tewodros, A., Melese, L., and Yoseph, T. 2021. Assessment of the production and importance of cowpea [*Vigna unguiculata* (L.) Walp]: Cases from selected districts of southern Ethiopia

Abstract

Cowpea *[Vigna unguiculata* (L.) Walp] is a vital legume in the hot, dry tropics and subtropics of sub-Saharan Africa, serving multiple roles in the livelihoods of millions of people with relatively low incomes. The entire plant can be used for either human or livestock consumption, or it has considerable drought-tolerating capacity. Tender young leaves, green pods, and mature seeds are used as food for humans. Moreover, the crop contributes to sustainable soil fertility improvement due to its excellent nitrogen-fixing capacity. However, its production and utilization are limited in Ethiopia, partly due to dependence on conventional agronomic practices and lack of information on its wide-ranging uses. This study was conducted to assess the cowpea agronomy and the contributions the crop makes to the livelihoods of farmers at Loka-Abaya and Humbo districts of southern Ethiopia. Multi-stage sampling techniques were employed to achieve the set objectives. Both primary and secondary data were collected to obtain the required information. The data were subjected to descriptive and inferential statistics, including a multiple linear regression model, using SPSS software version 20 and STATA 13. The results of the multiple linear regression model showed that education, land size, access to climate information, credit access, lack of market chain, availability of seed for improved varieties, and pests significantly ($P < 0.001$) affected cowpea production in the study areas. The trend analysis showed that the cowpea yield and production area are increasing in Humbo District, whereas a decreasing trend was observed in Loka Abaya. According to the household interview data, about 76% of respondents reported a decrease in the cultivated area of cowpea. According to the respondents, the lack of access to improved seeds and the lack of extension support services contributed 79% and 73%, respectively, to the low yield observed in the area. Most respondents cultivate cowpea as an intercrop or in rotation with cereals, primarily to replenish soil fertility (97%).

On the other hand, 62% of the respondents cultivate cowpea for home consumption. According to the survey result, 48% of the respondents use the mature grain for consumption. The production trends of cowpea are highly variable, mainly due to the limited attention paid by extension systems to boost crop yields, farmers' reliance on local varieties, pest occurrences, and a poor market chain. Therefore, modern production technologies, including the supply of improved seed varieties with their full production package, should be introduced to the area to improve yields and optimize their contribution towards achieving food security.

Keywords: agronomy, climate variability, food security, humbo, Loka-Abaya, semi-arid

DOI: https://doi.org/10.18697/ajfand.102.19630

Influence of temperature and screw pressing on the quality of cassava leaf fractions

Citation

Ayele, H.H., Latif, S., and Müller, J. 2021. Influence of temperature and screw pressing on the quality of cassava leaf fractions

Abstract

In this study, the development of a mild processing method for cassava leaves to remove cyanogenic compounds with minimum nutritional loss was evaluated. Fresh leaves were reduced in size using a mixer at temperatures of 25 °C (room temperature), 55 °C, 80 °C, and 100 °C for 1 min before screw pressing to separate the juice and press-cake fractions. Cyanide content in the fresh leaves was reduced by 60% at 100 °C and by 57% in the juice sample processed at 25 °C. The cyanide content in the press cake was low (210 ppm) in both the control and the sample processed at 55 °C. An increase in the processing temperature for cassava leaves to 100 °C resulted in a loss of 5–13% of the crude protein (CP) and 7–18% of the vitamin C content. The press-cake fraction had high contents of beta-carotene, lutein, and chlorophyll a and b content, while the juice fraction had lower values. 'Processing fresh cassava leaves at 25 °C and 55 °C resulted in fractions with high contents of beta-carotene and lutein. The protein quality of the press cake was better than that of the juice for feed. Short thermal shredding followed by pressing resulted in minimal loss of nutrients and a significant reduction of cyanide in the leaves.

Keywords: Cassava leaves, nutrients, cyanide, press cake, juice, pressing

DOI: https://doi.org/10.3390/agriculture12010042

Partitioning of proteins and anti-nutrients in cassava (*Manihot esculenta* Crantz) leaf processing fractions after mechanical extraction and ultrafiltration

Citation

Ayele, H.H., Latif, S., Bruins, M.E., and Müller, J. 2021. Partitioning of proteins and anti-nutrients in cassava (*Manihot esculenta* Crantz) leaf processing fractions after mechanical extraction and ultrafiltration

Abstract

Cassava plays a major role in improving food security and reducing malnutrition. The purpose of this study was to evaluate the influence of mechanical pressing coupled with ultrafiltration (UF) on the quality of different fractions of cassava leaves. Cassava leaves harvested from the greenhouse at the University of Hohenheim were processed through a mechanical screw press to extract the juice and separate the press-cake. The juice was centrifuged and filtered to separate the sediment and clear supernatant. The clear supernatant was filtered using a 10-kDa UF system. The nutrient contents of the different fractions were analyzed at each processing step. The total phenolic content was significantly lower in the press cake, which had a higher fiber and ash content. The juice and sediment fractions had higher crude protein and total phenolic content. Processing did not negatively affect the concentrations of essential amino acids, except for tryptophan in the juice fraction. Non-protein nitrogen was mainly present in the UF permeate, illustrating the potential of UF for upgrading soluble protein fractions. The results indicated that the different fractions obtained during processing could be a source of protein for food, feed (juice, sediment, and retentate), or fiber (press cake) in ruminant feed.

Keywords: cassava leaves, juice, press cake, mechanical pressing, ultrafiltration, mild processing, fractionation

DOI: https://doi.org/10.3390/foods10081714

Production, reproduction, and some adaptation characteristics of Boran cattle breed under changing climate: A systematic review and meta-analysis

Citation

Bayssa, M., Yigrem, S., Betsha, S., and Tolera, A. 2021. Production, reproduction, and some adaptation characteristics of Boran cattle breed under changing climate: A systematic review and meta-analysis

Abstract

Climate change affects livestock production and productivity, potentially threatening livestock-based food security in tropical and subtropical pastoral and agropastoral systems. The Boran cattle breed is one of the hardiest Zebu cattle reared by Borana Oromo pastoralists for milk and meat production. However, there is limited comprehensive information available on production, reproduction, and adaptation traits of the Boran cattle in Ethiopia. Thus, this paper aimed to compile the main production, reproduction, and adaptation traits of Boran cattle based on a systematic review and meta-analysis of peer-reviewed, published, and unpublished literature. A combination of systematic review and meta-analysis based on the PRISMA guideline was employed. Accordingly, out of 646 recorded articles identified through database searching, 64 were found to be eligible for production, reproduction, and adaptation characteristics of the Boran cattle; 28 articles were included in a qualitative systematic review, while 36 articles were used for quantitative meta-analysis. The Boran cattle breed can survive, produce, and reproduce under high ambient temperatures, utilize low-quality forage resources, and resist water shortages, long watering intervals, and tick infestations. The review revealed that the breed employs various adaptive responses (morphological, physiological, biochemical, metabolic, cellular, and molecular) to cope with harsh environmental conditions, including climate change, rangeland degradation, seasonal feed and water shortages, and high incidences of tick infestations. The meta-analysis, employing a random-effects model, provided pooled estimates of heritability and genetic correlations for reproduction and production traits, which could be used to solve genetic prediction equations at the population level in purebred Boran cattle. In addition, the heritability and genetic correlation estimates found in the present study suggest that there is high genetic variability for most traits in Boran cattle, and genetic progress is possible for all studied traits in this breed.

Keywords: Boran cattle, climate change, reproductive performance, adaptive traits, meta-analysis

DOI: https://doi.org/10.1371/journal.pone.0244836

Yield response of field-grown cowpea varieties to *Bradyrhizobium* inoculation

Citation

Ayalew, T., Yoseph, T., Petra, H., and Cadisch, G. 2021. Yield response of field-grown cowpea varieties to *Bradyrhizobium* inoculation

Abstract

Cowpea *[Vigna unguiculata* (L.) Walp.] is a widely cultivated crop for food and animal feed, with a high potential for alleviating the effects of climate change on crop yields due to its biological nitrogen-fixing ability. However, its yields are low in Ethiopia, partly due to poor agronomic practices, such as the lack of improved varieties, low soil fertility, and limited use of inputs, including bio-inoculants. Field experiments were conducted during the cropping seasons of 2018 and 2019 at three sites in Ethiopia that are vulnerable to climate change and food insecurity (Boricha, Dore, and Hawassa) to determine the yield responses of cowpea varieties to *Bradyrhizobium* inoculation. Four cowpea varieties, Keti (IT99K-1122), TVU, black eye bean, and White Wonderer, were tested in combination with three inoculation levels (uninoculated or inoculated with *Bradyrhizobium* strains CP-24 or CP-37) in a factorial randomized complete block design with four replications. Results revealed significant varietal differences in crop yield and yield components over years and across sites. Averaged over the seasons, the seed yield of TVU was 52% higher than that of the low-yielding black eye bean variety. Across the three sites, on average, inoculation of cowpea with strain CP-24 resulted in significant increases in seed yield (21%), pod number (16%), and 100-seed weight (13%) compared to the control. Furthermore, the interaction between variety and inoculant resulted in a significant increase in seed yield and number of pods per plant of TVU × CP-24 by 60% and 68%, respectively, as compared to the uninoculated treatment. Overall, inoculating the cowpea varieties TVU and White Wonderer Trailing with *Bradyrhizobium* strain CP-24 is recommended at all three tested sites and in similar agroecological environments for improved cowpea productivity.

Keywords: agronomy, biological nitrogen fixation, climate change effect, food security, seed yield, sustainable production

DOI: https://doi.org/10.1002/agj2.20763

Role and *in vivo* localization of *Fusarium oxysporum* f. sp. *strigae* and *Bacillus subtilis* in an integrated *Striga hermonthica* biocontrol system

Citation

Anteyi, W.O. and Rasche, F. 2021. Role and *in vivo* localization of *Fusarium oxysporum* f. sp. *strigae* and *Bacillus subtilis* in an integrated *Striga hermonthica* biocontrol system

Abstract

To improve the efficiency of *Striga hermonthica* biological control within an integrated biocontrol system, the role and impact of inoculating the mycoherbicide *Fusarium oxysporum* f. sp. *strigae* (*Fos*) with a plant growth-promoting rhizobacterium, *Bacillus subtilis* isolate GB03, on *S. hermonthica* attachment and sorghum biomass was investigated. *Fos* isolates (Foxy-2, FK3) and GB03, including *Trichoderma viride* (IMB 12098 strain) as reference, were applied as single and combined treatments to *S. hermonthica*-infested rhizoboxes with sorghum as the host crop. In vivo localization/interaction of *Fos* and GB03 in *S. hermonthica* was monitored by fluorescent gene expression of transformed *Fos* and transformed GB03. Combined treatments of FK3+GB03 and Foxy-2+GB03 increased sorghum above-ground dry biomass ($P < 0.05$) but did not for IMB12098+GB03. None of the combined treatments suppressed *S. hermonthica* attachment. Single treatments of FK3 and GB03 increased sorghum above-ground dry biomass ($P < 0.05$), but Foxy-2 and IMB12098 did not. Only FK3, among all single treatments, suppressed *S. hermonthica* attachment ($P < 0.05$). GB03 promoted sorghum yield when applied alone or in combination with *Fos* ($P < 0.05$). *Fos* penetration of *S. hermonthica* through trichome entry was revealed. Although *Fos*, either as sporal (conidia) or vegetative form (mycelium), co-occupied common ecological niches with GB03 (they co-localize) in diseased *S. hermonthica* shoots, mainly in flavonoid-rich regions. Nevertheless, GB03 thwarted *Fos* suppressive activity against *S. hermonthica* attachment. In the given setup, coinoculation of *Fos* with GB03 presented no added advantage in suppressing the incidence of the sampled *S. hermonthica*.

Keywords: *Striga hermonthica*, *Fusarium oxysporum* f. sp. *strigae*, Foxy-2, FK3, *Bacillus subtilis* GB03, ecological niche, plant/microbe-microbe interactions

DOI: https://doi.org/10.1094/PHYTOFR-08-20-0011-R

Model-based yield gap analysis and constraints of rainfed sorghum production in Southwest Ethiopia

Citation

Habte, A., Worku, W., Gayler, S., Ayalew, D., and Mamo, G. 2020. Model-based yield gap analysis and constraints of rainfed sorghum production in Southwest Ethiopia

Abstract

For ensuring food demand of the fast-growing population in developing countries, quantifying crop yield gaps and exploring production constraints are very crucial. Sorghum is one of the most important climate change resilient crops in the rainfed farming systems of the semi-arid tropics. However, there is little information about yield gaps and production constraints. This study aimed to analyze existing yield gaps and explore the major constraints to sorghum production in Southwest Ethiopia. A crop simulation model approach, utilizing AquaCrop and DSSAT, was employed to estimate potential yields and analyze yield gaps. Model calibration and evaluation were performed using data from field experiments conducted in 2018 and 2019. Sorghum production constraints were assessed using a survey. The actual and water-limited yield of sorghum ranged from 0.58 to 2.51 and 3.6 to 6.47 t/ha, respectively, for the period 2003–17. The regional yield gaps for sorghum during the targeted period ranged from 3.02 to 3.95 t/ha, with a mean value of 3.51 t/ha. Most respondent farmers considered seasonal rainfall risk (98%), poor soil fertility (86%), lack of improved varieties (78%), and inadequate weed management (56%) as major factors responsible for the existing yield gaps. The mean exploitable yield gap (2.5 t/ha) between water-limited and actual yield showed the level of existing opportunity for improvement in the actual productivity of sorghum. The gaps also call for the introduction of proper interventions, such as the adoption of improved varieties, adjusting planting dates, conservation tillage, fertilizer application, and timely weed management.

Keywords: Actual yield, AquaCrop, DSSAT, potential yield, simulation, survey

DOI: https://doi.org/10.1017/S0021859621000435

Downscaling of seasonal ensemble forecasts to the convection-permitting scale over the Horn of Africa using the WRF model

Citation

Mori, P., Schwitalla, T., Ware, M.B., Warrach-Sagi, K., and Wulfmeyer, V. 2021. Downscaling of seasonal ensemble forecasts to the convection-permitting scale over the Horn of Africa using the WRF model

Abstract

The new SEAS5 global ensemble forecast system was dynamically downscaled over the Horn of Africa for summer (June-July-August) 2018. For this purpose, a multi-physics ensemble was designed with a grid spacing increment of 3 km and without any intermediate nest based on the Weather Research and Forecasting model (WRF). The WRF and SEAS5 model outputs were compared with each other and reference datasets to assess biases in four different regions of Ethiopia. Also, the WRF ensemble variability was investigated in relation to model parameterization and lateral boundary conditions. Over the summer, the SEAS5 had a positive temperature bias of 0.17 °C compared to the ECMWF analysis average for the study domain, whereas the WRF bias was +1.14 °C. Concerning precipitation, the WRF model had average accumulated values of 264 mm, compared to 248 mm for SEAS5 and 236 mm for the observations. Over south Ethiopia, however, the downscaling produced over 50% more precipitation than the other datasets. The maximum northward extension of the tropical rain belt was reduced by about 2° in both models when compared to observations. Downscaling increased the reliability of precipitation, correcting the SEAS5 underdispersion: the ensemble spread for precipitation was increased by approximately 70% in the WRF ensemble in three of the four Ethiopian sub-regions, whereas the very dry Somali Region remained unaffected. The WRF ensemble analysis revealed that the perturbed boundary conditions primarily contribute to the ensemble spread, as their effect is often 50% larger than the physics-induced variability in the mountainous region of Ethiopia for precipitation and temperature.

Keywords: convection-permitting, downscaling, ensemble, Ethiopia, SEAS5, seasonal forecast, WRF

DOI: https://doi.org/10.1002/joc.6809

Tripartite interaction between *Striga* spp., cereals, and plant root-associated microorganisms: A review

Citation

Mounde, L.G., Anteyi, W.O., and Rasche, F. 2020. Tripartite interaction between *Striga* spp., cereals, and plant root-associated microorganisms: a review

Abstract

Striga spp. is a major threat to cereal and legume production, posing a severe risk to the food security and economic stability of smallholder farmers in sub-Saharan Africa. This is manifested in the fact that *Striga* spp. infestation can result in a loss of up to 90% of both cereal and legume production. A consensus exists that there is yet no single measure to efficiently control *Striga* spp. This is primarily due to the limited fundamental knowledge of the genetics and ecology of *Striga* spp. and its interactions with its hosts and host root-associated microorganisms, including plant growth-promoting rhizobacteria (PGPR). Since *Striga* spp. is a root parasite, it is speculated that PGPR play a key role in controlling the emergence and development of *Striga* spp. At the same time, PGPR may exhibit beneficial effects on the growth promotion of the host, thereby strengthening its tolerance against *Striga* spp. attacks, while on the other hand, it may also induce, similar to biocontrol agents, direct suicidal effects on *Striga* spp. Such hypothesized associations between *Striga* spp., crops (e.g., cereals such as sorghum and maize), and PGPR remain largely unknown, and the central question remains whether PGPR play a significant role in the *Striga*-crop pathosystem. This knowledge gap is the central impetus of this review. It will elaborate on the complex and fascinating tripartite ecological system of cereals, *Striga* spp., and root-associated microorganisms. In the first step, the review will provide a comprehensive summary of the pairwise interactions between *Striga* spp. and cereals, between cereals and PGPR, and between *Striga* spp. and PGPR. This summary will then be integrated into the discussion about the currently limited knowledge of the tripartite interaction between cereals, *Striga* spp., and PGPR. This specifically includes the exploration of recent discoveries related to population genetics and the life cycle of *Striga* spp. host (cereal) defense responses to and mechanisms of *Striga* spp. infestation, as well as the inhibitory and stimulatory role of PGPR on *Striga* spp. seed germination. In a concluding section, remaining research gaps are identified, and necessary research perspectives are provided to direct prospective research toward further understanding the relationship between the three biological components, thereby paving the way to develop biological and environmentally friendly measures to combat the enduring threat of *Striga* spp.

Keywords: *Striga* spp., cereals, rhizosphere, plant growth-promoting rhizobacteria (PGPR), tripartite interaction, biological control

DOI: https://doi.org/10.1079/PAVSNNR202015005

Symbiotic effectiveness of inoculation with *Bradyrhizobium* isolates on cowpea [*Vigna unguiculata* (L.) Walp] varieties

Citation

Ayalew, T. and Yoseph, T. 2020. Symbiotic effectiveness of inoculation with *Bradyrhizobium* isolates on cowpea [*Vigna unguiculata* (L.) Walp] varieties

Abstract

Cowpea [*Vigna unguiculata* (L.) Walp] is one of the widely cultivated crops, contributing to sustainable farming development due to its excellent nitrogen contribution via symbiosis. The response of *Bradyrhizobium* inoculants depends on the compatibility of the strain and the legume crop. Therefore, the current work aimed to evaluate the symbiotic effectiveness of the *Bradyrhizobium* isolates with cowpea varieties tested on sand. For this purpose, five *Bradyrhizobium* isolates (CP-24, CP-10, CP-37, GN-33, and GN-102) and five cowpea varieties [Keti (IT99K-1122), TVU, black eye bean, White Wonderer Trailing, and Bole] were used. The experiment was arranged using CRD, with three replicates. The result of the experiment showed significant ($P \leq 0.05$) differences for all the measured parameters. White Wonderer Trailing inoculated with CP-24 exhibited the highest plant height (28.33 cm), whereas the lowest plant height was recorded when Keti (IT99K-1122) variety was inoculated with GN-102. The highest nodule number per plant (47.67) was recorded in the CP-24 inoculated black eye bean variety. The highest nodule dry weight was recorded from the CP-24 inoculated TVU variety. A pink nodule color and green leaves were observed in the cowpea varieties inoculated with *Bradyrhizobium* isolates. For all the parameters considered, the control treatments showed significantly lower performance compared with the inoculated treatments. Hence, this study demonstrates the need for *Bradyrhizobium* inoculation to enhance growth, biomass, and nodulation performance. Furthermore, these isolates can be used for the field production of cowpea in the study area and similar agroecologies.

Keywords: BNF, isolates, effectiveness, legumes, nodulation, symbiosis

DOI: https://doi.org/10.1080/23311932.2020.1845495

Population genetic structure and marker–trait associations in East and West African *Striga hermonthica* with varying phenotypic response to *Fusarium oxysporum* f. sp. *strigae* isolates Foxy-2 and FK3

Citation

Anteyi, W.O. and Rasche, F. 2020. Population genetic structure and marker–trait associations in East and West African *Striga hermonthica* with varying phenotypic response to *Fusarium oxysporum* f. sp. *strigae* isolates Foxy-2 and FK3

Abstract

To examine the genetic basis for the variable susceptibility of *Striga hermonthica* from differing zones of sub-Saharan Africa to *Fusarium oxysporum* f. sp. *strigae* (Fos) isolates Foxy-2 and FK3, 10 *S. hermonthica* populations from Eastern and Western Africa were phenotyped for their susceptibility response to Foxy-2 and FK3, and then genotyped with 22 simple sequence repeat (SSR) markers. There is low genetic differentiation between East African and West African *S. hermonthica* populations (i.e., the proportion of the total genetic variance contained in the subpopulation relative to the total genetic variance, FST = 0.012, $P < 0.05$). Still, intermediate genetic differentiation (FST = 0.143, $P < 0.01$) underlies the *S. hermonthica* groups that are differentiated by their phenotypic responses to Fos isolates. An expressed sequence tag SSR (EST-SSR) marker Y53 ($P < 0.01$) and a genomic SSR marker E1009 ($P < 0.05$) were associated with the *S. hermonthica* class susceptible to Foxy-2 and FK3 (group A). A divergent *S. hermonthica* class, consisting of groups with intermediate susceptibility to Foxy-2 (group B) and susceptibility to either FK3 (group C) or Foxy-2 (group D), showed no marker–trait association; instead, it demonstrated linkage disequilibrium decay. Owing to point substitutions and insertion–deletion mutations, the unique, protein-coding nucleotide sequence at the E1009 locus in group A was partly dissimilar to that of group B. However, it was distinctly different from groups C and D. These findings suggest that the inconsistent effectiveness of a Fos isolate is better explained by genomic variation in *S. hermonthica*, rather than by the sampling zones *S. hermonthica*.

Keywords: *Striga hermonthica*, *Fusarium oxysporum* f. sp. *strigae*, Foxy-2, FK3, population genetic structure, marker–trait association

DOI: https://doi.org/10.1111/tpj.14930

Conclusion

This *Book of Abstracts* showcases the breadth and depth of scientific work generated through CLIFOOD across nearly a decade of collaborative research, training, and capacity building. The 57 abstracts, authored primarily by early-career African scholars, span climate-resilient agriculture, crop and livestock production, climate modeling, sustainable food systems, nutrition, and environmental sustainability, with a strong focus on Ethiopia within Eastern Africa.

The implications are far-reaching. Many studies provide actionable guidance to enhance agricultural productivity, strengthen smallholder resilience, improve resource use efficiency, and inform climate risk management and adaptation. Collectively, the findings offer practical entry points for policymakers, development partners, and extension services seeking to scale evidence-based, inclusive interventions.

The close of CLIFOOD Phase II in 2025 marks a transition from project to legacy, with enhanced institutional capacity among partner universities, strengthened research leadership among PhD graduates and postdoctoral fellows, and a growing uptake of research outputs in policy and practice. By investing in high-quality education and solution-oriented research, CLIFOOD has laid the foundations for sustained locally anchored contributions to the Sustainable Development Goals, especially SDG 2 (Zero Hunger), SDG 13 (Climate Action), SDG 4 (Quality Education), and SDG 17 (Partnerships for the Goals). CLIFOOD's impact endures through the scholars it has empowered, the partnerships it has deepened, and the knowledge it has generated. The outcomes documented here underscore the value of transdisciplinary cross-regional collaboration and the need for predictable, long-term support for graduate training and applied research in Africa, where responses to climate-related food system risks must be locally led, inclusive, and science-based.

We hope this Book of Abstracts will serve as a lasting reference, a springboard for new collaborations, and an invitation to dialogue among researchers, practitioners, and policymakers committed to building food-secure, climate-resilient futures in Eastern Africa and beyond.

Book of Abstracts

A Compilation of Peer-Reviewed Research by Doctoral Candidates

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