Role of biotechnology in advancing African agriculture for planetary health

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Biotechnology offers transformative solutions to the critical challenge of enhancing agricultural productivity with the principles of planetary health, which emphasise the intrinsic link between human well-being and the integrity of Earth's natural systems. In Africa, where food insecurity, climate stress, and environmental degradation intersect, innovative approaches are needed to sustainably increase food production while safeguarding ecosystems. Modern biotechnologies, particularly genome editing, enable the development of climate-resilient, nutrient-rich, and pest- and disease-resistant crops without introducing foreign DNA. These tools allow for the sustainable intensification of agriculture, producing more food on less land, with fewer inputs, thus reducing pressure on biodiversity, soil, and water systems. In African contexts, genome editing is being applied to key staple crops such as banana, maize, sorghum and yam to combat threats like bacterial wilt, lethal necrosis, and parasitic weeds such as Striga, while enhancing nutritional content. These innovations not only improve food security but also contribute to climate adaptation and ecological sustainability. To fully realise these benefits, African nations must foster enabling environments with science-based, transparent regulatory frameworks. Progress is underway, as seen in several African countries, where national guidelines for genome editing have been established. This presentationr will highlight recent advancements in genome editing and explore how biotechnology can serve as a catalyst for resilient, equitable, and environmentally sustainable agriculture across Africa and beyond, central to the vision of planetary health.

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Performance and yield stability of maize under a long-term experiment in the sub-humid tropics

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Zea mays L. is an important staple cereal crop to the food security and livelihoods of people worldwide. We evaluated the effects of organic and conventional farming systems on maize growth and temporal yield stability under different external input levels in a long-term experiment (18-years and on-going) at two sites (Chuka and Kandara) in Central Kenya. The experiment was based on a three-year crop rotation cycle. Maize sole-crop was cultivated during the long rains' (LR) seasons at the start of each crop-rotation cycle. We implemented the following four farming systems: organic high (Org-High), conventional high (Conv-High), organic low (Org-Low), and conventional low (Conv-Low) in a randomised complete block design. Fortnight scouting reports were utilised to manage pests and diseases in the experimental sites. The sites experienced rainfall variation over the years and within seasons. We observed declining total rainfall amounts during the maize sole-cropping (LR) seasons. Crop growth parameters; height, stem diameter, and grain yield were higher in high input systems, but grain yield stability was not. At the beginning of the experiment, grain yields of conventional systems were higher compared to the organic systems, whose yield levels gradually increased over time, reaching the yield levels of conventional systems. At Chuka, Org-High generally had higher grain yields except in LR07 and LR22, while at Kandara, the Org-High system had the highest yields during the LR13, LR16, and LR22 seasons. With regard to grain yield stability, the site (Chuka) with better soil fertility, the Conv-High system had the least residual variance (0.28 Mg ha^{-2}), followed by Org-Low, Conv-Low, and Org-High showing the highest residual variance (0.67 Mg ha^{-2}). Contrary, in the site (Kandara) with low soil fertility, Org-Low had the lowest residual variance in grain yield (0.16 Mg ha^{-2}), followed by Conv-Low and Org-High, while Conv-High (4.15 Mg ha^{-2}) had the highest residual variance. We observed that applying higher nutrient input levels did not necessarily lead to yield stability. Our findings suggest promoting long-term implementation of organic farming practices, especially in regions with degraded soils, for improved yield and resilience.

Keywords: Agroecology, crop rotation, farming system, nutrient replenishment, soil fertility, yield trend

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Evaluating sustainable maize intensification strategies in smallholder farming systems in northern Ghana

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Context-specific management practices supporting sustainability are crucial for maintaining maize productivity in smallholder farming systems, particularly in northern Ghana in the face of declining soil fertility, sub-optimal use of inputs and the increasing erratic weather. This study employed the Agricultural Production Systems simulator (APSIM) to assess the performance of sustainable intensification practices; sole application of inorganic fertilizer or manure, combination of both, different maturity duration maize varieties (Obatanpa and Abontem), and different planting dates across three districts – Tolon, Savelugu, and Mion in Northern Ghana. Calibration and evaluation relied on on-station (Nyankpala) and farm-level experiments (19 farmer fields from Dimabi and Langa). Grain and biomass yield were adequately simulated with Relative Root Mean Squared Error (RRMSE) below 14 %. RMSE for days to anthesis and maturity were 2.1 and 1.7 days, respectively. Combined use of manure and inorganic fertilizer generally produced the highest grain yields for both cultivars across all locations, with yield gains ranging from 116 — 369 % compared to the control (no fertilizer or manure is applied) based on simulation results using multi-year climate data (1984 – 2024). Tolon (with the lowest soil Organic Carbon (OC %)) recorded the lowest grain yield, while Mion (highest OC %) produced the highest yield across all treatments. Yield variability (CV) under the fertility treatments was generally lowest for Mion (8.7), while Tolon recorded the highest average variability of 12.4. The sustainability of yield (SYI) was highest for treatments that combined inorganic fertilizer and manure for both cultivars. Across sites, Mion had the highest SYI with values from 0.43 — 0.88 for Obatanpa and 0.47 -– 0.88 for Abontem. Interannual standard deviation (INST) was highest for Mion and least for Tolon. INST indices generally decreased with increasing SYI at all locations. Doubling inorganic fertilizer from 30 to 60 kg N ha^{-1} increased grain yield across all locations and varieties by 28–57 %. Early sowing windows yielded more grain with higher SYI than late sowings. These findings offer practical guidance for extension services and policy to promote locally appropriate sustainable intensification in smallholder farming systems needed to enhance food security and the resilience of agri-food systems in northern Ghana.

Keywords: Crop modelling, low-input systems, maturity duration, site-specific, yield stability

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Intercropping immature oil palms with food crops: Effects on oil palm growth

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Oil palms take 3–4 years to start producing after replanting. Farmers regularly plant food crops in the space between immature palms. There is little research available about intercropping in immature oil palm fields. We report the state-of-the-art of oil palm intercropping research and we present some results of a two-year oil palm intercropping project with smallholders and a large company in Bengkulu, Indonesia.
Our field research consisted of two parts: 1) A one-time observational study in smallholder fields (monoculture vs intercrop; n=29), and 2) Observations in an intercropped block of a large-scale plantation. In the large plantation, 11.3 ha were intercropped with watermelon in the first year after replanting, and bananas were established on 15 ha (partly overlapping with the watermelon area) in the following year. We established monitoring plots in an imbalanced pseudo-replicated design with four treatments: watermelon followed by monoculture (n=4), watermelon followed by banana (n=4), monoculture followed by banana (n=6) and monoculture followed by monoculture (n=9). We collected vegetative growth parameters for the oil palms (four timepoints over 21 months) and visually inspected the data without statistical testing, as we used a pseudo-replicated design.
No differences in oil palm vegetative growth were observed between monoculture and intercropped smallholder fields. In the large-scale plantation, the data suggest that oil palms fronds were larger in plots that were intercropped previously with watermelon. Intercropping with banana did not lead to visible changes in frond size and palm height. These trends were consistent over time.
We observed a potential positive effect of watermelon on oil palm. This may be due to irrigation, fertiliser application and weeding in the intercropped fields. There was confounding with the position in the landscape; watermelons were cultivated in low-lying areas where irrigation water was accessible. For banana intercropping, fertiliser inputs may lead to positive effects, but competition for light is a serious concern. Our data are inconclusive but suggest that intercropping does not necessarily reduce oil palm growth and may even promote it. Rigorous long-term studies on effects of intercropping on future oil palm yields are required.

Keywords: Banana, frond size, large-scale plantation, oil palm, smallholders, watermelon

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Performance of lettuce (*Lactuca sativa* L.) under different shading levels in Sant-Louis, Senegal

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Climate change with its consequences of increasing temperatures, solar radiation, and evapo-transpiration can negatively influence vegetable growth, yield, and quality, particularly in hot tropical regions. Integrating vegetables into agroforestry systems could be a solution, but no data on such systems are available in Senegal. Shade nets, which imitate shade of trees, can be tested as a mitigation method and for assessing species-specific responses to the prevailing microclimatic conditions under shade. The objective of this study was to assess the effects of different shading levels on agronomic performance of lettuce (*Lactuca sativa* L.). The experiment was conducted at the experimental farm of Gaston Berger University in Saint-Louis, Senegal, using shade nets with three different shading levels. The experimental design adopted was a completely randomised block design with three replications. The treatments used were: 0 % (no shade), 35 % shade, 55 % shade and 75 % shade. Total biomass (including roots), above-ground biomass and marketable yield (old/damaged outer leaves removed) were assessed from six plants per plot. Data were processed using analysis of variance and post-hoc Tukey test. The results showed that shade level had a significant effect on total biomass ($p = 0.017$), above-ground biomass ($p = 0.015$), and marketable yield ($p = 0.004$). Lettuce grown under the 55 % shade net showed the best performance with high average total biomass (145 g), above-ground biomass (134 g) and marketable yield (126 g) per plant. Lettuce cultivated in full sun (0 % shading) showed poor performance with lowest results for the above mentioned parameters (68 g, 58 g and 46 g, respectively). Lettuce grown under the 35 % and the 75 % shade nets showed medium performance with intermediate values for the assessed three variables. Our results suggest that intermediate shading levels in lettuce production systems could be a practical and efficient strategy for improving lettuce productivity in regions exposed to high heat stress. Further tests of lettuce production under the shade of trees should be performed to find out if lettuce is a suitable vegetable species for integration into agroforestry systems.

Keywords: Agroforestry systems, horticulture, microclimate, shade net, vegetable

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Performance of *Crotalaria juncea* and *Lablab purpureus* in three agro-ecologies of Kenya

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The availability of high-quality forage is a major limitation to livestock productivity in sub-Saharan Africa. Integrating resilient, high-yielding forage legumes into mixed farming systems offers a practical approach to addressing seasonal shortages especially crude protein. In the current study, we evaluated the agronomic performance of 4 forage legumes including three *Lablab purpureus* lines and one *Crotalaria* spp. Two *Lablab purpureus* varieties namely, Jhansi (ILRI accession No. 6529) and Highworth (ILRI accession No. 147) were obtained from International Livestock Research Institute gene bank in Addis Ababa while Lablab cv Maridadi, currently grown by farmers was used as a check. Three contrasting agroecological zones in Kenya were selected including, lower highland (LH3), upper midland (UM2) and lower midland 1(UM1). The trial design was Randomised Complete Block Design (RCBD). Data on plant height and dry matter (DM) yield were collected over two seasons.

Plant height varied significantly between species, sites, and seasons. *Crotalaria juncea* consistently attained the tallest plants across all locations. The average plant height for *Crotalaria juncea* ranged from 1.28 m – 1.45 m. Lablab varieties exhibited plant heights ranging between 0.50 m – 0.85 m. Differences in plant height among lablab accessions were not statistically significant. Dry matter yield was also influenced by both site and season. *Crotalaria juncea* accumulated 7.92 t ha^{-1} at lower midland 1 and 14.32 t ha^{-1} in upper midland 2. Significant differences between lablab ILRI 147 and ILRI 6529 were observed with highest yields at upper midland 2, with ILRI 147 accumulating 20.23 t ha^{-1} over the two years. Consistently, *Lablab* cv Maridadi had the lowest yields across sites and seasons, with a cumulative value of 8.27 t ha^{-1} recorded at the upper midland 2 site. The high dry matter production of ILRI 147 and ILRI 6529 at lower midland sites highlights the potential of these in semi-arid conditions. Integrating these legumes into smallholder systems could significantly enhance quality feed resources and contribute to more sustainable livestock production in Kenya and similar regions.

Keywords: Agroecology forage nutrition, forage legume, semi arid

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Combined effects of vapour pressure deficit and nitrate to ammonium ratio on the growth of *Chenopodium quinoa* in hydroponics

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The scarcity of freshwater resources necessitates the exploitation of alternative water sources and the adoption of more efficient farming methods. Hydroponics combined with treated wastewater offers a promising solution for food production, yet high ammonium (NH_4^+) levels in wastewater can hinder plant growth in these systems. To investigate the influence of ammonium to nitrate (NO_3) ratios on quinoa (*Chenopodium quinoa* Willd.) growth under contrasting vapour pressure deficits (VPDs), we cultivated the variety Titicaca in a deep-water flow system for 30 days at a low VPD of 1.2 kPa and a high VPD of 4.0 kPa. Nutrient solutions of four NO_3N:NH_4-N ratios (100:0, 85:15, 65:35, and 50:50) were used. The total nitrogen concentration was maintained at approximately 3.0 mM by adding stock solutions every third day. Simultaneously, the pH was adjusted to 5.3–6.3 using HCl or NaOH, as needed. During the experimental period, samples of the nutrient solutions were taken daily for analysis and plants were harvested every sixth day for biomass partitioning.
At high VPD, the general assumption that a low NH_4^+ concentration promotes plant growth in hydroponic systems was confirmed. A 85:15 NO_3:NH_4^+ ratio significantly enhanced shoot dry biomass (70.2 ± 4.1 g) compared to the other high VPD treatments. Conversely, under low VPD, the pure NO_3 treatment yielded the highest shoot biomass (63.0 ± 4.6 g). Nutrient uptake analysis revealed a consistent preference for NO_3 across all treatments and VPD conditions, with NO_3 comprising approximately 65 % of total nitrogen uptake even at the 50:50 NO_3:NH_4^+ ratio. Notably, total nitrogen uptake was generally higher under high VPD, except for the pure NO_3 treatment. These findings demonstrate that VPD significantly influences the optimal NO_3:NH_4^+ ratio for maximising quinoa biomass in hydroponic systems, offering valuable insights for optimising treated wastewater utilisation in agriculture.

Keywords: Controlled environment farming, hydroponics, VPD, wastewater

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Productivity and land use efficiency of seven finger millet cropping systems in Chad

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Food insecurity and malnutrition poses a significant challenge in Chad, driven by factors such as poverty, conflict, and the impacts of climate change. The CROP4HD project promotes agroecology, crop diversification, and the use of nutrient-rich Neglected and Underutilised Species (NUS) for smallholder farmers, aiming to foster diverse and healthy diets to combat hunger and malnutrition.

Finger millet [*Eleusine coracana* (L.) Gaertn.] has been identified as a high-potential crop due to its rich nutritional content such as protein, calcium, phytates and phenolics. However, finger millet production in Chad remains exceedingly low, and little research has been conducted on optimising its cropping systems. Traditionally, finger millet is planted using a broadcasting technique. While this method can save time, it often results in uneven seed distribution, poor germination rates, challenges in weed management and reduced yields.

The objective of this study was to evaluate the productivity and land use efficiency of seven finger millet cropping systems under organic conditions. We tested four pure stands: broadcasting finger millet at 10 kg ha□[1], sowing finger millet in rows (25 cm × 25 cm) with and without board bending and a transplanting system from nursery to field (25 cm × 25 cm) with board bending. Additionally, we assessed three strip intercropping systems, which involve four rows of finger millet alternating with two rows of legumes (bambara bean, groundnut, or cowpea). The three legumes in pure stand were evaluated as well.

A field experiment was conducted at the Ba-Illi Agricultural Technical School in the Chari-Baguirmi region, situated in southwestern Chad, characterised by a semi-humid tropical climate during the rainy seasons (Mai-October) of 2023 and 2024, following a randomised complete block design with three replications.

Preliminary results indicate that the pure stand finger millet cropping system with transplanting has the highest yield potential, while the intercropping systems with bambara bean and with groundnut show stronger yield performance than intercropping with cowpea. According to farmers' perceptions, the cropping systems that combine finger millet with bambara beans and groundnuts are the most appreciated.

Keywords: Cropping system, *Eleusine coracana*, intercropping, land use efficiency, participatory research, productivity

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Arrangement, timing, and synergy: Rethinking maize-soybean intercropping for productivity gains in Southern Africa

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Intercropping improves resource-use efficiency and crop synergy. In Southern Africa, adding soybean to maize systems can increase total yield and protein output per area. This study assessed maize–soybean intercropping under varied spatial (sole, within-row, 1-1, 2-2, 4-4 strips) and temporal (Early, Medium, Late) arrangements at Chitedze (Malawi), Villa Ulongue (Mozambique), and Msekera (Zambia) using split-plot design in the 2022-2023 and 2023-2024 cropping seasons, replicated four times. Key parameters included soil moisture, chlorophyll (SPAD), grain yield, harvest index (HI), and total land equivalent ratio (TLER).

Soil moisture during flowering (maize) and podding (soybean) was highest in early/medium plantings. At Chitedze, moisture reached 5.7 % compared to 4.2 % in late. At Msekera, 2:2 and 4:4 strips retained 44 % and 32 %, respectively above 25.5 % in sole cropping.

Chlorophyll content followed moisture and yield dynamics. Chitedze: SM Early (69.8), 2:2 Early (65.3), WR Early (62.7); lowest: 4:4 Late (42.4). Villa Ulongue: highest SM Early (58.9), second WR Early (56.3), lowest SS Late (42.1). Msekera: highest WR Early (60.2), second SM Early (58.7), lowest 4:4 Late (30.6).

TLER favoured early strip systems: 4:4 Early (4.71), 2:2 Early (4.31) at Chitedze; Villa Ulongue 4:4 Early (2.37); Msekera 2:2 Early (1.56).

Soybean yields peaked: Chitedze 2:2 Early (2,392.7 kg ha^{-1}); Msekera 4:4 Early (2,288.1); Villa Ulongue 4:4 Early (2,245.6).

Maize yields: Chitedze SM Early (3,564.2), Villa Ulongue SM Early (3,285.7), Msekera SM Early (3,177.3).

Overall, early and medium planting with 2-2 and 4-4 strips improved yields and TLER compared with sole cropping, offering productive, protein-rich systems for smallholders.

Keywords: Chlorophyll content, grain yield, harvest index, intercropping, land equivalent ratio, maize, planting windows, soil moisture, soybean

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Assessing the effect of pruning on growth and yield enhancement in climate-resilient rice farming practices in coastal flood-prone area

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Pruning represents a new technique for increasing rice growth and productivity, with the objective of optimising this staple food in Indonesia. The effects of climate change, including erratic weather patterns, soil salinity, and saltwater intrusion, particularly in coastal regions, present significant challenges to the sustainability of rice farming. Pruning has the potential to optimise nutrient allocation, stimulate the optimal air circulation, improve input efficiency, and stimulate productive tiller growth. However, pruning of rice is uncommon in Indonesia. This study evaluates the effect of pruning timing in various rice varieties to achieve maximum rice yield potential. This research was carried out as farmer-led research in Bojong Village, Pangandaran Regency, West Java. The research was conducted from December 2024 to March 2025 growing season, to evaluate the impact of pruning on the growth characteristics of rice varieties. Field research used eco-climate friendly farming techniques, such as : organic fertiliser, mechanical and biological pest and disease control. This study used a randomised block design (RBD) with two factors and 3 replications. The first factor included five rice varieties: Baroma (V1), Inpari-43 (V2), Inpari Genah (V3), Mantap (V4), and Ngaos mawar (V5). The second factor included three pruning times: without pruning (P0), 28 days after transplanting (DAT) (P1), and 42 DAT (P2). The interaction between rice variety and pruning timing significantly affected several yield components. The findings of this study indicate that the optimal pruning timing varies significantly depending on the rice genotype and its associated growth and development characteristics. Pruning at 28 DAT is more suitable for superior rice varieties, namely Inpari-43 and Inpari Genah and pruning at 42 DAT is more effective for local rice varieties, including Baroma, Mantap and Ngaos mawar. Pruning can be conducted effectively at 25–35 % of the rice varieties harvest age, calculated based on days after sowing. The findings highlight the significance of variety specific pruning strategies in enhancing rice productivity, optimising plant architecture, improving nutrient uptake, and supporting yield stability under variable climate conditions. The implementation of pruning has the potential to contribute to the development of more resilient and sustainable rice farming practices in Indonesia.

Keywords: Climate adaptation, pruning, rice productivity, timing, variety

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