1. 研究活動（2022 年 4 月～ 2023 年 3 月）

1.1 研究活動概要

(1) 乾燥地研究センターについて

乾燥地研究センターは国立大学法人鳥取大学の独立部局であると同時に、共同利用・共同研究拠点である。その設置目的は、「乾燥地における砂漠化や干ばつなどの諸問題に対処し、乾燥地における自然－社会系の持続性の維持・向上に資する研究を中核的研究教育拠点として推進し、乾燥地科学分野の研究者の利用に供すること」にある。

本拠点形成の目的は、研究面においては、乾燥地研究センターがその前身を含めてこれまでに蓄積した砂地における植物生産や植生回復に関する知見と技術を、広く世界の乾燥地土壌に適用可能なものへと高度化するとともに、これに社会経済分野や医学分野などの知見や技術を融合させて、世界の砂漠化対処に資する、健康的な人間生活の営みを保障する「新たな乾燥地科学」を構築することにある。一方、教育面においては、大学院生（修士課程、博士課程）、研究生、JICA 等からの外国人受託研修員等の教育を担当し、乾燥地の砂漠化対処に関わる国際機関や企業、NGO などが必要とする研究者や技術者を養成することである。

本拠点の形成は、世界の乾燥地科学の発展、国連砂漠化対処条約に係る我が国の貢献義務の履行及び当該分野の人材育成にとって重要な意義を有する。

乾燥地研究センターの恒川篤史教授を研究代表者とする研究課題『砂漠化対処に向けた次世代型「持続可能な土地管理（SLM）」フレームワークの開発』（平成 29 年度～令和 4 年度）が、科学技術振興機構（JST）の国際科学技術共同研究推進事業「地球規模課題対応国際科学技術協力プログラム（SATREPS）」平成 28 年度新規課題に採択され、平成 29 年度から相手国エチオピアにおいて国際共同研究を展開している。

さらに、乾燥地研究センターの辻本壽教授を研究代表者とする研究課題『スーダンおよびサブサハラアフリカの乾燥・高温農業生態系において持続的にコムギを生産するための革新的な気候変動耐性技術の開発』（令和元年度～令和 5 年度）も、SATREPS 平成 30 年度新規課題に採択され、令和元年度から相手国スーダンにおいて国際共同研究を展開している。

加えて、乾燥地研究センターの坪充教授を日本側研究代表者とする研究課題『アフリカの多様な環境における農業気候リスク管理のためのレジリエントｅファーミングの開発』が、科学技術振興機構（JST）の戦略的国際共同研究プログラム「AJ-CORE（Africa-Japan Collaborative Research）」に採択され、令和 3 年度から国際共同研究を展開している。

乾燥地研究センターの石井孝佳准教授を研究代表者とする研究課題『染色体脱落の克服による遺伝資源概念の拡張』が、科学技術振興機構（JST）の創発的研究支援事業に採択され、令和 3 年度から共同研究を展開している。

乾燥地研究センターの山中典和教授を日本側研究代表者とする研究課題『トゥラニア・ユーラシア生態系における塩生植物の生産性と気候変動レジリエンス』が、日本学術振興会とロシア基礎科学財団との二国間交流事業（共同研究）に採択され、令和 3 年度から共同研究を展開している。

令和 4 年 9 月に九州大学農学部（伊都キャンパス）で

1. Research Overview (April 2021–March 2022)

1.1 Outlines of Research Activities

(1) About Arid Land Research Center

The Arid Land Research Center is an independent in terms of research, the objective of the center is to upgrade the knowledge and technologies accumulated by the ALRC, including its predecessors, on plant production and vegetation recovery in sandy soils to those that can be widely applied to arid lands worldwide, and to integrate this with knowledge and technologies in the fields of social economy and medicine to build a "new arid land science" that will contribute to combating desertification in the world and ensure healthy human life. On the other hand, in terms of education, the center provides education for graduate students (master's and doctoral programs), research students, and visiting training participants from JICA, etc., with the aim of training researchers and engineers needed by international organizations, companies, and NGOs involved in combating desertification in arid regions.

The establishment of the center is extremely significant in terms of further advancement in the world's dryland sciences, fulfillment of Japan's obligation to contribute to the United Nations Convention to Combat Desertification, and human resource development in this field.

The research project "Development of Next-Generation Sustainable Land Management (SLM) Framework to Combat Desertification" (FY 2017-2022), led by Professor Atsushi Tsunekawa of the ALRC, was selected for the FY2016 Science and Technology Research Partnership for Sustainable Development (SATREPS) of the Japan Science and Technology Agency (JST), and international joint research has been conducted in the partner country Ethiopia since FY 2017.

In addition, the research project entitled "Development of Climate Change Resilient Innovative Technologies for Sustainable Wheat Production in the Dry and Heat Prone Agro-Ecologies of Sudan and Sub-Saharan Africa" (FY 2019-2023), led by Professor Hisashi Tsujimoto of the ALRC, was selected for the FY2018 SATREPS, and international joint research has been conducted in the partner country Sudan since FY 2019.

Furthermore, the research project entitled "Development of Resilient E-farming for agro-climate risk management in African Multi-environment", led by Professor Mitsuru Tsubo of the ALRC, was selected for the Strategic International Collaborative Research Program "AJ-CORE" of the JST, and international joint research has been conducted since FY2021.

The research project entitled "Expansion of Genetic Resource Concept by Overcoming Chromosome", led by Associate Professor Takayoshi Ishii of the ALRC, was selected for the Fusion Oriental Research for disruptive Science and Technology of the JST, and joint research has been conducted since FY2021.

The research project "Climate resilience and productivity of halophytes in Turanian-Eurasian Ecosystems", led by Professor Norikazu Yamanaka of the ALRC, was selected for the FY2021 Japan-Russia Research Cooperative Program between JSPS and RFBR, and joint research had been conducted since FY2021.

Hiroki Nakahara, a research scientist at the ALRC (JSPS Research Fellow), and his colleagues received the Excellent

開催された日本生物環境工学会 2022 年大会にて、乾燥地研究センターの中原浩貴研究員（JSPS 特別研究員）らの研究発表「青枯病菌の表現型変異株によるトマトの病害防御関連遺伝子の発現誘導」がポスター賞優秀賞を受賞した。

令和 4 年 9 月にオンライン開催された第 2 回国際小麦会議（2nd International Wheat Congress）において、乾燥地研究センターのモハメド・バラプロジェクト研究員が「Exploiting wild emmer wheat diversity to improve wheat A and B genomes in breeding for heat stress adaptation（高温耐性育種のための野生エンマコムギの A および B ゲノムの多様性の利用）」の研究発表にて優秀ポスター賞を受賞した。

乾燥地研究センターの谷口武士准教授が「生態系の多機能性指標から示されるように、菌根菌の優占度はモンゴルの草地管理の鍵である（Dominance of arbuscular mycorrhizal fungi is key for Mongolian steppe management under livestock grazing, as indicated by ecosystem multifunctionality）」の研究にて、令和 4 年度鳥取大学科学研究業績表彰を受賞した。本研究は Ecological Indicators において出版され、その研究成果は広く公表されている。

組織・運営体制

本センターは、センター長、副センター長、教授会（教授、准教授等で構成）、運営委員会（外部委員、学内委員、センター専任教授で構成）及び共同研究委員会（外部委員、センター専任教授で構成）、3 研究領域、乾燥地植物資源バンク室、及び事務部で組織され、その運営は、教授会と運営委員会によって行われる。なお、鳥取大学技術部は平成 24 年度より組織が一元化され、1 つの部局となったが、これまでと同様、業務依頼及び技術支援による相互連携を図っている。

研究領域は、砂漠化対処領域、乾燥地農業領域、気候変動対応領域の 3 研究領域から構成され、専任の教授 6 名、准教授 5 名、助教 1 名、特命助教 3 名、国内客員 4 名、外国人研究員 3 名が配置されている。また、プロジェクト研究員 4 名が配置された。事務系には職員 15 名（事務職員 6 名、事務補佐員 9 名）、技術系には職員 12 名（技術職員 4 名、技術補佐員 8 名）が配置され、研究・教育の支援事務などを担当している（人数は令和 5 年 3 月 31 日時点）。

共同研究、教育、刊行物

令和 4 年度における共同利用研究代表者 (大学教員など) は 53 名、指導学生数は 36 名（博士課程 20 名、修士課程 12 名、学部学生 3 名、研究生 1 名、うち留学生 26 名（中国 4 名、エチオピア 9 名、スーダン 7 名、ナイジェリア 2 名、モンゴル 1 名、ケニア 2 名、ブルキナファソ 1 名））である。

共同研究に関する研究発表会は毎年開催しており、令和 4 年度は、12 月 3 日～ 4 日に本学において開催した。発表会の様子は一部を除きライブ配信されると同時に、英語による同時通訳配信を行った。

教育については、博士前期課程（持続性社会創生科学研究科）及び博士課程（連合農学研究科）に「国際乾燥地科学専攻」を設置し、学部－修士－博士の一貫教育を整備している。

定期刊行物としては、鳥取大学乾燥地研究センター年

Poster Award for their poster entitled, "Induction of expression of disease defense-related genes in tomato by phenotypic mutant strains of bacillus subtilis," at the 2022 Annual Meeting of the Japanese Society of Agricultural, Biological and Environmental Engineers and Scientists, held in September 2022 at Kyushu University Faculty of Agriculture (Ito Campus).

Dr. Mohamed Bala, Project Researcher at the ALRC, received the Excellent Poster Award for his poster entitled, "Exploiting wild emmer wheat diversity to Exploiting wild emmer wheat diversity to improve wheat A and B genomes in breeding for heat stress adaptation" at the 2nd International Wheat Congress held online in September 2022.

Associate Professor Takeshi Taniguchi of the ALRC received the 2022 Tottori University Scientific Achievement Award for his research entitled, "Dominance of arbuscular mycorrhizal fungi is key for Mongolian steppe Dominance of arbuscular mycorrhizal fungi is key for Mongolian steppe management, as indicated by ecosystem multifunctionality." This research was published in Ecological Indicators and the results have been widely disseminated.

Organization and Management Structure

ALRC consists of the Director, Vice Director, Faculty Council, Advisory Committee, Joint Research Committee, three research areas, the Laboratory of Arid Land Plant Resources, and the Administration Department. The administration is carried out by the Faculty Council and the Advisory Committee. The Technical Departments of Tottori University integrated their organizations into a department in FY2012, but as in the past, maintains mutual links based on business requests and technical support.

The Research Division is composed of three divisions: Division of Desertification Control, Dryland Agriculture, and Climate Change Response. As of March 31, 2023, six full-time professors, five associate professors, one assistant professor, three specially appointed assistant professor, four visiting professors from Japan and three foreign research scholars were allocated to these research divisions. In addition, four project researchers were added to our research teams. Moreover, 15 office staff (six full-time and nine part-time) and 12 technical staff (four full-time and eight part-time) supported ALRC's research and education.

Joint Research, Education, Publication

In FY2022, 53 joint-use research principal investigators, mainly from national and private universities, were attached to ALRC. In addition, ALRC had a total of 36 students; 20 Ph.D. students, 12 master's students, three undergraduate student and one research students, including 26 students were from overseas; four Chinese, nine Ethiopian, seven Sudanese, two Nigerian, one Mongolian, two Kenyan, and one Burkinabé.

ALRC holds the Joint Research Symposium every year, and in FY2022, the conference was held on December 3-4, at the University. All but a few of the presentations were streamed live with simultaneous interpretation provided in English.

Concerning education, the course "Global Dryland Science" was established for Master's course (Graduate School of

報を発足以来毎年刊行し、センターの研究教育活動の紹介を行っている。また、センターの活動を地域で支え、その研究活動と成果を広く情報発信することを通じて地域の発展を図る組織として設立された「とっとり乾地研倶楽部」の支援により、広報誌を年 3 回発行し、最新の活動状況等を紹介している。

研修施設

平成 23 年 8 月には、学外の共同研究者や学生が研究及び研修のために宿泊できる研修施設（ゲストハウス）が完成した。この施設は、ツインルーム 2 室、シングルルーム 4 室、研修室 1 室を備えている。

アウトリーチ活動

乾燥地研究センターでは、国内外や地域の人々にセンターを知ってもらうため、施設見学や体験学習などを積極的に受入れている。また、研究成果を広く社会に還元するため、一般市民や研究者を対象としたシンポジウム、パネル展等のイベントを開催している。

令和 4 年度は新型コロナウイルスの世界的感染拡大の影響が継続しているなか、オンラインや対面において研究成果の発信や一般公開等を実施した。

令和 4 年度の主な活動は以下のとおり。

●鳥取大学地域連携エクステンション活動「キャンパスで環境を学ぼう」: 令和 4 年 10 月 16 日、参加人数 8 名

●一般公開：新型コロナウイルス感染症の影響を考慮し、規模を縮小した対面開催とオンライン開催のハイブリッド形式により実施した。対面開催は 7 月 24 日で、飯田准教授による公開講演「日本の国際貢献～途上国の緑と生活を守る日本人の取り組み」の他、キャンパスツアーを行った。参加人数 38 名。オンライン開催では、センター紹介動画の YouTube 公開、Google Street View を利用したアリドドーム見学を実施した。

●日本・モンゴル外交関係樹立 50 周年記念特別展「邂逅する写真たち――モンゴルの 100 年前と今」への協力: 令和 4 年 3 月 17 日～ 5 月 31 日、主催 : 国立民族博物館、大阪府吹田市

Sustainability Science) and Doctoral course (United Graduate School of Agricultural Sciences). This course offers a consistent educational system through undergraduate, master's and doctoral courses.

Annual report has been published since the establishment of ALRC, which provides information and data about the research and education activities. In addition, ALRC issues newsletters three times a year to introduce its latest research activities, supported by the "Tottori Kanchiken Club" established by a local business association.

Accommodation Facility

A guest house was built in August 2011, which is available for joint researchers and students who want to stay in the premises of ALRC for research activities and training. This accommodation facility has two twin rooms, four single rooms and one training room.

Outreach Activities

ALRC has been conducting various outreach activities such as facility tours and training programs to promote and publicize ALRC's activities both inside and outside Japan. In addition, ALRC has been holding a number of events such as symposia and panel exhibitions to disseminate research outcomes and achievements to public and outside researchers.

In FY2022, while the effects of the global spread of the Covid-19 infection continued, we disseminated research results online and in person, and made them available to the public.

We held the following activities during FY2022.

● Tottori University Regional Collaboration Extension Activity "Let's Learn about the Environment at Tottori University": October 16, 2022, ALRC. 8 participants

● Open House Event: Considering the impact of the Covid-19 infection, the Open House was held in a hybrid format of in-person and online events on a reduced scale.

The face-to-face event was held on July 24, and featured a lecture by Associate Professor Iida on "Japan's International Contribution ～ Japanese Efforts to Protect Greenery and Livelihoods in Developing Countries" and campus tours. The number of participants was 38.

The online event included a YouTube video introducing the ALRC and a tour of the Arid Dome using Google Street View.

● Special Exhibition "100 Years of Mongolia: Encounters through Photography": March 17- May 31. 2022, Presented by the National Museum of Ethology, Suita City, Osaka Prefecture

(2) 研究領域

1) 気候変動対応領域

恒川 篤史（保全情報学）

保全情報学分野では，乾燥地における植物生産および生態系変化のモニタリングとモデリングを中心的課題としている。特に水やダストを介しての大気と陸域（植生と土壌）の間の相互作用の解明や，乾燥地における生態系・地域社会の持続可能性を評価する手法の開発に力を入れている。そのため数値モデル・リモートセンシング・GIS などの情報技術とフィールドでの観測，乾燥地研究センターにおける施設実験などを組み合わせながら、以下のような研究を進めている。

1. 生態系プロセスモデルを用いた環境応答の予測
2. リモートセンシング・GIS を用いた生物生産力の広域的推定
3. 乾燥地における持続可能性の評価手法の開発
4. 持続可能な土地管理（SLM）に関する研究

本年度は、土壌侵食に関連して、Revised Universal Soil Loss Equation (RUSLE モデル) における C 因子および P 因子に関する 255 の学術論文をレビューすることによって人間活動と気候変数に起因する両因子の変動を分析し、以下のような研究結果を得た。

気候帯、土地利用や被覆タイプ、支援方法によって、両因子値に大きなばらつきがあることがわかった。C 因子の平均値は乾燥地域（0.26）から湿潤地域（0.15）へと減少したのに対し、P 因子の平均値は増加した（それぞれ 0.33 から 0.47)。世界の平均 C 因子は､耕作地 (0.34) から森林（0.03）まで 1 桁異なる。P 因子は、耕作地の区画の等高線の 0.62 から、未耕作地のトレンチの 0.19 の範囲であった。

Ebabu K, Tsunekawa A, Haregeweyn N, Tsubo M, Adgo E, Fenta AA, Meshesha DT, Berihun ML, Sultan D, Vanmaercke M, Panagos P, Borrelli P, Langendoen EJ, Poesen J. JUN 2022. Global analysis of cover management and support practice factors that control soil erosion and conservation. International Soil and Water Conservation Research 10(2): 161-176.

(2) Research Divisions

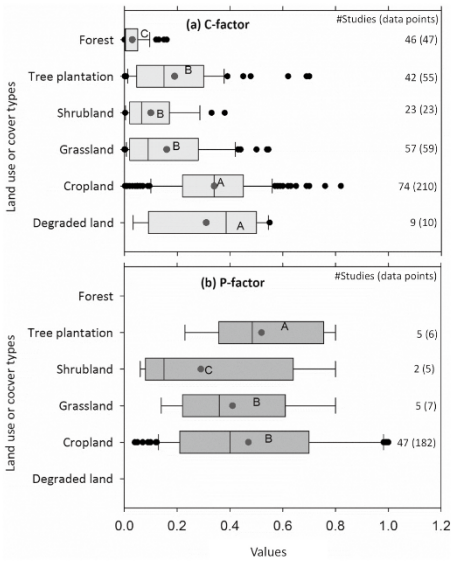
1) Division of Crimate Change Response

Atsushi Tsunekawa (Prof., Conservation Informatics)

The Conservation Informatics Subdivision conducts research on the monitoring and modeling of the plant production and ecosystem change in the dry lands. Particular efforts are being made to clarify the interaction between the atmosphere and the land surface (vegetation and soil) through water and dust, and to develop methodologies for evaluating the sustainability of ecosystems and local communities in dry lands. The research of the Subdivision is driven by combining the use of information technologies such as numerical modeling, remote sensing and geographic information systems (GIS); field observations; and experiments using ALRC's facilities for the following topics.

1. Prediction of environmental response using a process-based ecosystem model
2. Regional estimation of biological productivity using remote sensing and GIS
3. Development of methodologies for evaluating sustainability in drylands
4. Study on sustainable land management (SLM)

We obtained the following research findings about the variation in C- and P-factors caused by human activities and climatic variables by reviewing 255 published articles reporting measured or calculated C- and P factor values. We found a wide variation in both factor values across climatic zones, land use or cover types, and support practices. The average C-factor values decreased from arid (0.26) to humid (0.15) climates, whereas the average P-factor values increased (from 0.33 to 0.47, respectively). Thus, support practices reduce soil loss more effectively in drylands and drought-prone areas. The global average C factor varies by one order of magnitude from cropland (0.34) to forest (0.03). Among the major crops, the average C-factor was highest for maize (0.42) followed by potato (0.40), among the major orchard crops, it was highest for olive (0.31), followed by vineyards (0.26). The P-factor ranged from 0.62 for contouring in cropland plots to 0.19 for trenches in uncultivated land. The C-factor results indicate that cultivated lands requiring intensive site preparation and weeding are most vulnerable to soil loss by sheet and rill erosion.



坪　充（気候リスク管理学）

気候リスク管理学分野では、農業気象、微気象および作物モデルに関する研究を進め、以下について活動している。

(1) 農業干ばつモニタリング
(2) 乾燥地農業モデリング
(3) 農業気象情報システムの開発

今年度は、以下の研究を行った。

乾燥地作物モデルの開発

アフリカの乾燥地農業では、播種や施肥などの栽培管理における革新的な意思決定が、農家の気候変動への対処策のひとつとなる可能性がある。既存の作物モデルは、最適な栽培管理計画を探るために利用できるが、これらのモデルは様々な入力データを必要とし、アフリカでは入手できない可能性が高い。このことが、作物モデルシミュレーションに基づく農家意思決定支援システムの開発を妨げている。そこで本研究は、作物生育の主要プロセスに関するアルゴリズムの簡略化を図り、スマホアプリ意思決定ツールに実装可能な作物モデルを開発することを目的とした。キャノピー光利用、播種施肥および土壌水分ストレスに関するモジュールから成る作物生長モデルを開発し、開花や登熟の発育ステージについては、有効積算温度によって定義した。国際共同研究実施国（南アフリカおよびセネガル）の圃場実験で収集した作物収量データを用いて、モデル出力の検証を行っている。このモデルは、栽培パラメータと、日射量、気温、降雨量などの気候変数を最小限に抑えながら、作物収量を推定するのに十分であり、このようなモデルの特性すべては、農家がスマホアプリを利用しやすくするため、干ばつリスク管理における農家の意思決定を支援することができる。

Mitsuru Tsubo (Prof., Climate Risk Management)

The Climate Risk Management subdivision conducts research in agrometeorology, micrometeorology and crop modelling, particularly the following.

(1) Agricultural drought monitoring
(2) Dryland agricultural modelling
(3) Development of agrometeorological information systems

In the fiscal year, the following research was carried out.

Development of a dryland crop model

In African dryland farming systems, innovative decision-making in agronomic management such as seeding and fertilising is potentially one of the measures for farmers to cope with climate variability. Existing crop models can be used to explore optimum agronomic management strategies, but these models require various input data, which are most likely unobtainable in Africa. This hinders the development of farmers' decision-support systems based on crop model simulation. This study, therefore, aimed to develop a crop model that can be implemented in a smartphone app-based decision-making tool with simple algorithms for the key processes of crop growth and development. The crop growth model was developed with modules of canopy radiation use, seeding and fertilising, and soil moisture stress, and the growth stages such as the days to flower and maturity were defied using growing degree days. The model output has been tested against crop yield data collected from field experiments in international collaboration partner countries (South Africa and Senegal). This model is sufficient to estimate crop yield with a minimised number of agronomic parameters and climate variables such as solar radiation, air temperature and rainfall. All these characteristics of the model will facilitate the farmers' utilisation of the smartphone app and therefore support farmers' decision-making in drought risk management.

南アフリカにおけるインゲンマメ / トウモロコシ圃場実験
A dry bean and maize field experiment in South Africa

セネガルにおけるピーナッツ圃場実験
A groundnut field experiment in Senegal

飯田　次郎（国際開発協力学）

国際開発協力学分野では以下の研究を行っている。

（1）ユーラシアの乾燥地域において社会・文化、経済や対外関係の視点から見た国際開発協力に関する研究

（2）乾燥地において、ソーシャル・キャピタルに注目した生計向上等のプロジェクトの持続性に関する研究

今年度の成果は以下のとおりである。

（1 － 1）タジキスタン科学アカデミーと共同で、「未開発地域資源を活用した土壌生態系サービス開発による環境再生型農業と地域経済振興」に取り組む。タジク人のメンタリティーやタジキスタンの歴史、文化的背景、風土に合わせた環境再生型農業のビジネスモデルを総合知により社会実装することを目指す。

（1 － 2）国土の 70%が乾燥・半乾燥地域であるウズベキスタンを調査し、同国サマルカンド国立大学を訪問した。園芸作物の普及による農民の生計向上を第一として、食料安全保障を達成することは同国の重要政策であり、鳥取大学との協働に大きな期待がかかる。大統領の方針の下、将来同大学はアフガニスタンに対する支援の拠点となる構想も有している。2023 年 2 月に同大学長等を鳥取に招へいし学術交流協定を締結したほか、共同研究に向けたワークショップを開催した。

（2 － 1）エチオピアに 4 回出張し、現地での生計向上活動を調査した。これは、鳥取大学を中心に土壌浸食防止に総合的に対処する SATREPS 活動の一環で、鳥取大学で博士号を取った研究者がオーナーシップをもって取り組んでいる。現地では既存コミュニティに働きかけて共有地でアカシア植林を行い水食復旧に成功するなど、普及しうる事例が見られた。そのコミュニティでは、規範、意識づくり、信頼感の醸成などの社会関係資本（ソーシャル・キャピタル：SC）の活用による持続性の強化が認められた。

（2 － 2）モロッコからのかんがい技術者を対象に「節水かんがいシステム普及研修」を実施した（JICA から受託）。同国では干ばつで水不足が著しく深刻化し、点滴かんがいが進められる中で、点滴による局所灌漑に移行するには、農民自身による施設の維持管理が求められている。そこで、農家による水利組合について日本の事例を紹介した。鳥取市の福部土地改良区では、各農家組合員の「責任感」が維持管理活動に重要なことなど、水管理には、農家の意識を変えていくというソーシャル・キャピタルの強化が重要なことを体感できた。

Jiro Iida (Assoc. Prof., International Cooperation Development)

The International Cooperation Development Subdivision conducts research as follows:

(1) The international development cooperation in arid areas of Eurasia, from the viewpoint of society, culture, economy, and external policies

(2) Sustainability of the projects in arid areas, including livelihood improvement, focused on Social Capital

Following results were obtained in this fiscal year:

(1-1) Jointly with Tajik National Academy of Science, I engage in the subject "Promotion of regenerative farming and regional economy by developing the soil-ecosystem service with use of untapped regional resources". Considering the mentality of Tajik people, its history, culture and climate, the business model of the regenerative agriculture is expected to be implemented socially in a multidisciplinary manner.

(1-2) I had a study trip to Uzbekistan, where arid and semi-arid areas occupy 70% of the territory. Uzbek government puts the food security on higher priority and improves the farmers' livelihood by extending horticulture to farmers. Samarkand State University (SSU) intends to disseminate the results also to Afghanistan in future, following the president's initiative. In February 2023, Tottori University (TU) and SSU concluded the Academic Exchange Agreement and organized the workshop on the future joint research. We expect future collaboration with SSU.

(2-1) I had four official visits to Ethiopia and studied the livelihood-improving projects. They are the parts of the activities of SATREPS, under which TU copes with prevention of gully erosion. The researcher, who obtained PhD in TU, with a strong ownership, manages the activities. Utilizing the existing social structure, a community succeeded in rehabilitating gully erosion of the communal land by reforestation. Social Capital (SC), such as setting rules, fostering awareness and trust, are well utilized to strengthening the sustainability of the activities.

(2-2) We conducted the training for irrigation engineers from Morrocco, entrusted by JICA. We introduced the case in Tottori how to motivate water users' association organized by farmers. Moroccans recognize that each farmer should have a enough sense of responsibility as a key for success in O&M by farmers' collective. They understand the SC, such as a change of farmers' thinking, plays a key role in water management.

The researcher of Bahir Dar University facilitates and motivates villagers and farmers. He emphasizes the market-linkage is a drive for farmers in income-generating activities.

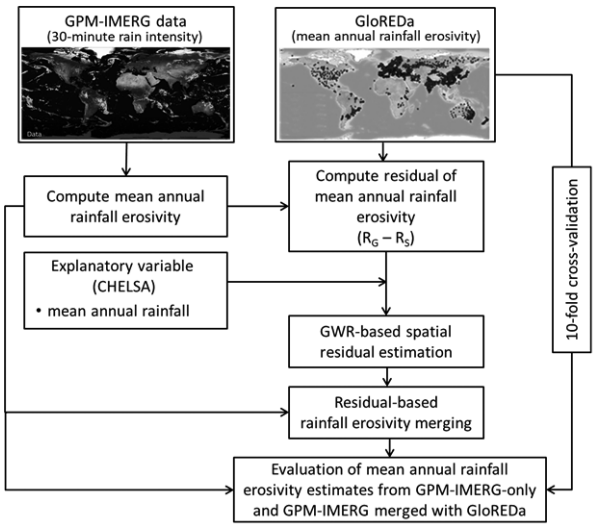
Moroccan participants learn O&M method of irrigation facilities by farmers' collective at the pump station of Fukube Land Improvement District in Tottori city.

Ayele A. Fenta (Specially Appointed Assoc. Professor, Remote Sensing Hydrology)

The division of International Research Unit of IPDRE under the field of remote sensing hydrology conducts research as follows:

•Improving satellite-based global rainfall erosivity estimates through merging with gauge data

With specific objectives: (i) develop a new global rainfall erosivity map based on long-term (2001–2020) satellite-based precipitation product—Integrated Multi-satellitE Retrievals for Global Precipitation Measurement (GPM-IMERG) merged with rainfall erosivity from the Global Rainfall Erosivity Database (GloREDa) stations (n = 3286), (ii) evaluate the performance of Geographically Weighted Regression (GWR)-based merging method based on the GloREDa data and 10-fold cross-validation, and (iii) identify areas prone to soil erosion by water through a coupled mapping of erosivity density (ED) and mean annual rainfall. The research was collaboratively conducted with researchers from the European Commission, Joint Research Centre (JRC).

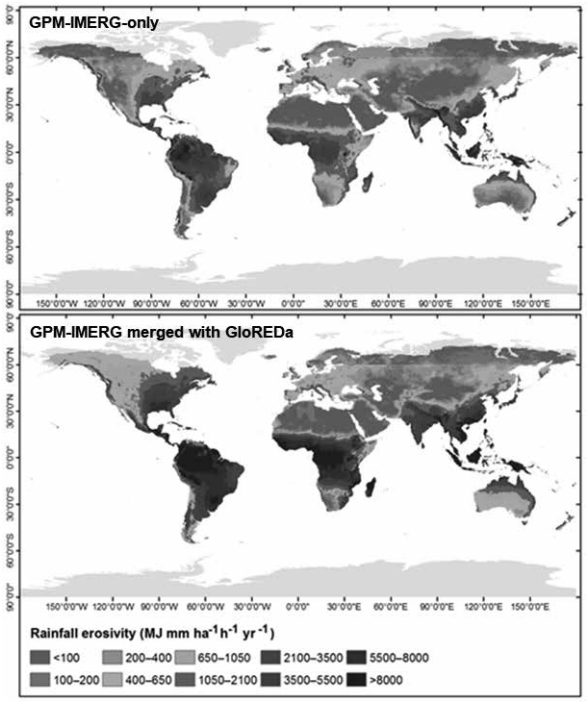


The general methodological framework of GWR-based merging of GPM-IMERG-based mean annual rainfall erosivity estimates with gauge data from the GloREDa

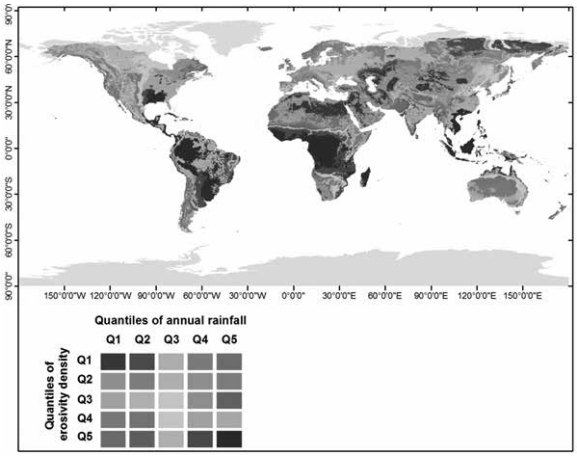
The following are the main results:

Based on GPM-IMERG-only, the global mean annual rainfall erosivity was estimated to be 1173 MJ mm ha^{-1} h^{-1} yr^{-1} with a standard deviation of 1736 MJ mm ha^{-1} h^{-1} yr^{-1}. The mean value estimated via GPM-IMERG merged with GloREDa was 2020 MJ mm ha^{-1} h^{-1} yr^{-1} with a standard deviation of 3415 MJ mm ha^{-1} h^{-1} yr^{-1}. Overall, GPM-IMERG-only estimates underestimated rainfall erosivity. The underestimations were greatest in areas of high rainfall erosivity. The accuracy of rainfall erosivity estimates from GPM-IMERG merged with GloREDa substantially improved (Nash-Sutcliffe efficiency = 0.83, percent bias = -2.4%, and root mean square error = 1122 MJ mm ha^{-1} h^{-1} yr^{-1}) compared to estimates by GPM-IMERG-only (Nash-Sutcliffe efficiency = 0.51, percent bias = 27.8%, and root mean square error = 1730 MJ mm ha^{-1} h^{-1} yr^{-1}).

The ED and mean annual rainfall have been classified into 25 categories that represent the five quantiles (Q1–Q5) of each dataset. Areas characterized by both very high EDs (>4 MJ ha^{-1} h^{-1}, Q5) and very high mean annual rainfall (>1200 mm, Q5) are very susceptible to soil erosion and/or landslides. Areas where very high ED (>4 MJ ha^{-1} h^{-1}, Q5) was accompanied by very low mean annual rainfall (<300 mm, Q1) were also identified as erosion-prone. The lowest-susceptibility areas were identified as those characterized by very low ED (<0.5 MJ ha^{-1} h^{-1}, Q1) and very low mean annual rainfall (<300 mm, Q1). Also, areas with high mean annual rainfall but very low ED due to an even distribution of rainfall are less susceptible to erosion.



Spatial distribution of mean annual global rainfall erosivity based on GPM-IMERG-only and GPM-IMERG merged with GloREDa station data. Erosivity classes correspond to quantiles of the GPM-IMERG merged with GloREDa



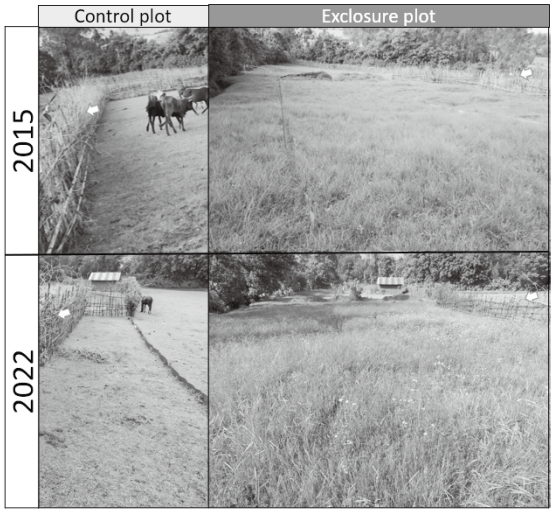
Potentially erosion-susceptible areas identified through coupled quantile mapping of ED and mean annual rainfall

Kindiye Ebabu GELAW (Specially Appointed Assistant professor, Soil Erosion and Sustainable Land Management)

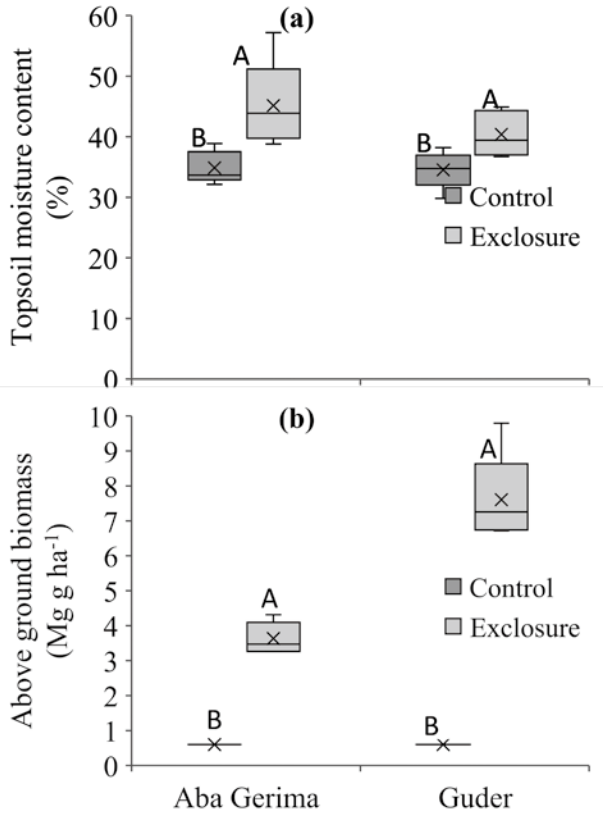
The sustainable land management subdivision of the SA-TREPS-Ethiopia project conducted research on development of low cost and accurate soil and vegetation restoration methods for degraded grasslands and hillsides in the Ethiopian highlands.

In the fiscal year 2022, I analyzed changes in biomass production and selected topsoil parameters in plots established with and without exclosure (fence) at two contrasting highland environments of Ethiopia (Aba Gerima and Guder). The analysis was made using quadrate-based biomass estimation and laboratory analysis of composite topsoil (0.20 m) samples collected at five locations across slope gradient in a 450 m2 plot. Soil and vegetation samplings were made eight years after experimental plots were set. Statistical analysis was performed to evaluate the significance of differences in biomass and soil parameters between plots with and without exclousre.

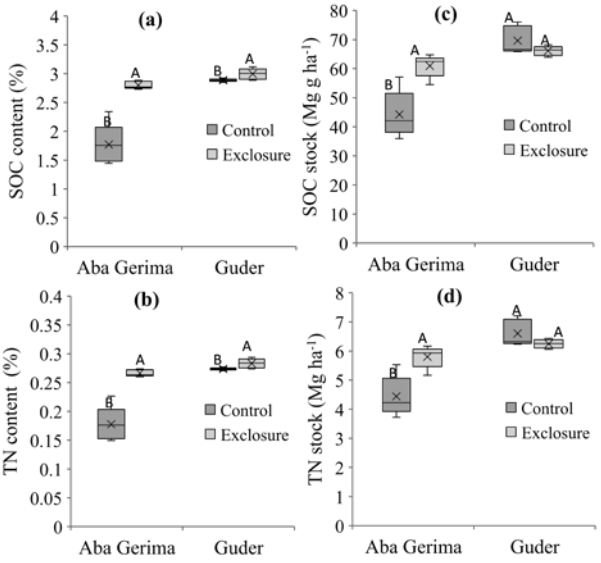
The results demonstrated significant differences in selected topsoil parameters between plots with and without exclosure. At Aba Gerima site, average moisture content, organic carbon content and total nitrogen content of topsoil were far higher from exclosure plot (45%, 2.8%, 0.27%) than from control plot (35%, 1.8%, 0.18%). At Guder site, although the soil organic carbon (SOC) and total nitrogen (TN) contents from exclosure plot were significantly higher than those from the control plot, the corresponding stocks in Mg ha^{-1} from control plot were found to be relatively higher. This was because soil bulk density (mass of soil per unit area) in control plot (1.21 Mg ha^{-1}) was greater than that from exclosure plot (1.10 Mg ha^{-1}). Regardless of the rates of change in topsoil parameters, the average above ground biomass yields from exclousre plots were 5 to 12 times higher compared to that from control plots. Thus, the results suggest that exclosure is the best way to restoring soil quality and productivity of degraded grasslands in regions, including drylands, where free grazing is prevalent.



Changes in above ground vegetation (grass) cover between control and exclosure plots at Guder site. Photos were taken at one year (August, 2015) and eight years (November, 2022) after establishment of experimental plots.



Box and whisker plots of topsoil moisture content (a) and rate of above ground biomass production from control and exclosure plots at Aba Gerima and Guder sites. In each site (Aba Gerima and Guder), boxes labelled with different letters indicate that the mean values (×) differ significantly between plots (Paired T-test, $P < 0.05$).



Box and whisker plots of SOC (a) and TN (b) contents in the topsoil from control and exclosure plots and corresponding stocks (Mg ha^{-1}) calculated as a function of bulk density (c and d). In each site (Aba Gerima and Guder), boxes labelled with different letters indicate that the mean values (×) differ significantly between plots (Paired T-test, $P < 0.05$).

2）砂漠化対処領域

山中　典和（緑化学）

緑化学分野では植物生態学に基礎をおいた乾燥地域の緑化及び砂漠化土地の生態系修復に関する研究を行っている。主要な研究テーマは以下の様である。

(1) 乾燥地における植物群落の生態学的研究
(2) 樹木の耐乾・耐塩性に関する生理生態学的研究
(3) 乾燥地の生態系修復に関する研究

これらの研究は、モンゴル、ウズベキスタン、中国等の研究機関、および国内の大学・研究機関と共同で行っている。今年はモンゴルとウズベキスタンでの海外調査を実施することができた。

1. 2022 年 8 月、モンゴル生命科学大学（旧モンゴル農業大学）のウンダルマ - 博士、乾燥地研究センターの寺本博士とともに、モンゴル内で降水量の異なるフスタイ、マンダルゴビ、ブルガンの 3 か所で植生調査及び土壌呼吸の調査を行った。降水量の減少に伴い、植生構造やバイオマスの変化が生じ、それとともに土壌呼吸速度も変化した。同時に、各調査地で放牧の影響が植生や土壌呼吸に与える影響についても調査を行った。

2. サトレプス・ウズベキスタン事業『アラル海地域における水利用効率と塩害の制御に向けた気候にレジリエントな革新的技術開発（代表：田中賢治、京都大学)』のメンバーとして、鳥取大学国際乾燥地研究教育機構のトデリッチ教授や三重大学の松尾博士と共に、6 月と 9 月にウズベキスタンで塩生植生及び塩生植物の調査を行った。今年度は、新型コロナによる移動制限により、研究対象地であるカラカルパクスタン州のアラル海周辺での調査は実現できず、隣接するキジルクム砂漠で調査を行った。

Field Survy at Fustai site with high precipitation (top) and Bulgan site with low precipitation (bottom). (Aug. 2022, Mongolia)

2) Division of Desertification Control

Norikazu Yamanaka（Prof.，Revegetation Science）

The Revegetation science subdivision conducts research on the revegetation in arid areas and ecosystem restoration of desertified lands based on plant ecology. Main research topics of revegetation science subdivision are as follows.

(1) Ecological studies on plant communities in arid lands
(2) Eco-physiological studies on drought and salt tolerance of woody plants
(3) Studies on the ecosystem restoration in arid lands

These studies are conducted in collaboration with research institutions in Mongolia, Uzbekistan, China, and other countries, as well as with universities and research institutes in Japan.

1. In August 2022, I conducted field study on vegetation and soil respiration in three locations with different amounts of rainfall in Mongolia (Hustai, Mandargobi, and Bulgan) together with Dr. Undarmaa of the Mongolian University of Life Sciences and Dr. Teramoto of the ALRC. As precipitation decreased, vegetation structure and biomass changed, and the rate of soil respiration changed with it. At the same time, the effects of grazing on vegetation and soil respiration were investigated at each study site.

2. As a member of the Satreps Uzbekistan project "The Project for Development of Innovative Climate Resilient Technologies for Monitoring and Controlling of Water Use Efficiency and Impact of Salinization on Crop Productivity and Livelihood in Aral Sea region (Representative: Kenji Tanaka, Kyoto University)" I conducted a survey of salt vegetation and Halophytes in Uzbekistan in June and September with Professor Toderich of the IPDRE, Tottori University, and Dr. Matsuo of Mie University. This year, due to movement restrictions imposed by the Covid19, we were unable to conduct surveys around the Aral Sea in Karakalpakstan, and instead conducted surveys in the adjacent Kizilkum Desert.

Halophytes research around salt lakes, Uzbekistan (June 2022)

黒崎　泰典（ダスト気候学）

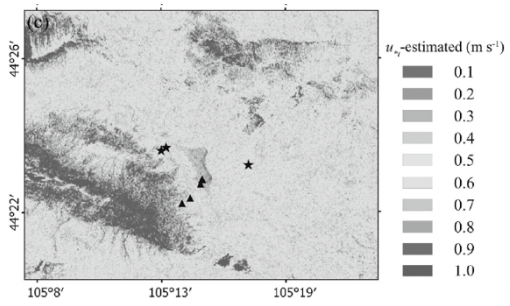
日本では黄砂として知られるダスト粒子（土壌粒子）は乾燥地や耕作地などにおいて強風によって舞い上がり、細かい粒子は自由対流圏の風によって長距離輸送される。発生域では気象災害の側面が強く、人や家畜の死亡・行方不明、建築物損壊などの被害をもたらす。発生域から遠くなるに従い、健康影響、酸性雨中和、海洋生態系への影響、放射過程・雲凝結過程を介した気候への影響といった環境影響の側面が強くなる。ダスト気候学分野では、主に (1) 日々のダスト空間分布モニタリング、(2) 発生原因解明とその黄砂数値モデルへの応用、(3) 日本に飛来するダストの沈着量、発生源解明を課題としている。

課題 (1) では、気象台データと MODIS 衛星画像を用いた東アジア準リアルタイムダストモニタリングシステムの維持更新を行ってきたが、元データとして利用していた MODIS Rapid Response System のサービスが終了したため、ひまわり 8 号・9 号画像等（気象庁 HP）で代用した。

課題 (2) では、新型コロナ感染拡大のため現地滞在による観測は実施しなかったが、Gantsetseg 氏 (IRIMHE) に依頼した観測及び植生調査は実施できた。昨年度、Buyantogtokh 氏（連合農学研究科）のレキ調査結果 (Buyantogtokh et al. 2021)、Wu 氏（気象研）の枯れ草調査結果 (Wu et al. 2021) を既存 GIS データ、衛星データを用いてダスト数値モデルに入力するための広域データを作成した。今年度、レキについては気象研との共同研究により数値モデル NHM-Chem-Dust にレキ効果を組み込んだ数値実験を行い、精度向上を確認した (Sekiyama et al. 2023)。Wu et al. (2023) において、枯れ草効果を導入すると、最もダストが発生する 4 月においてモデル精度が向上する可能性が高いことを報告した。Buyantogtokh et al. (2022) において、臨界摩擦速度を合成開口レーダー (SAR) 後方散乱係数から推定する手法を開発した。

課題 (3) では、乾地研共同研究（長田和雄・名古屋大）において、PM2.5 観測などを乾燥地研究センター屋上で実施した。JST ジュニアドクター育成塾・探究コースにおいて、乾性・湿性沈着観測の指導を行い、担当した中学生が JST サイエンスカンファレンスにおいて分野賞（最優秀賞）を受賞した。

これらは、環境研究総合推進費（課題番号 JPERF20205001）、科研費基盤 B（22H01310）、鳥取大学国際乾燥地研究機構経費、乾燥地研究センター共同研究において実施した。



Threshold friction velocities estimated from SAR backscatter coefficient in the Tsogt-Ovoo region on May 6, 2019 (Buyantogtokh et al. 2022).

Yasunori Kurosaki (Prof., Dust Climatology)

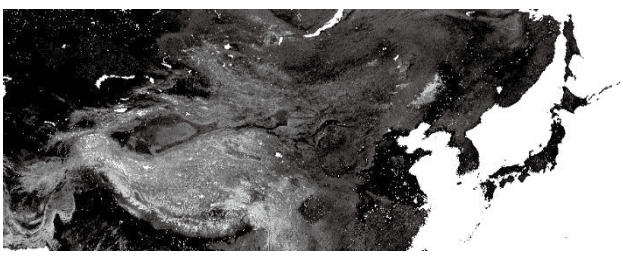
Mineral dust particles are blown up by a strong wind in arid land, agricultural area, etc., and fine particles are transported over a long distance by wind in free troposphere. In emission areas, it works as a disaster which leads death and missing of human and its livestock, damages on architectural facility, etc. In downwind areas, it brings adverse health effects such as respiratory disease and it changes environment change by neutralization of acid rain, marine ecosystem change, effects on climate, etc. The dust climatology subdivision has majorly three subjects, which are (1) monitoring of dust distribution, (2) elucidation of dust emission mechanisms and an application of them on numerical dust models, and (3) elucidation of the amount of deposited dust in Japan and its source regions. Major works in the fiscal year are described as below.

On the subject (1), the near-real time East Asia dust monitoring system using MODIS satellite images has been operated for long time. However, the service of MODIS Rapid Response System was over. Therefore, I substitute images from it with images of Himawari-8 & -9 satellites (JMA HP).

On the subject (2), no one could not attend on-site observations from Japan due to COVID-19. However, on behalf of us, Ms. Gantsetseg (IRIMHE) conducted some observations and vegetation surveys. Last fiscal year, I prepared datasets of stone and dead leave for a wide area by applying past field observation results of Buyantogtokh et al. (2021) and Wu et al. (2021), respectively. This fiscal year, in collaborative research with the Meteorological Research Institute (MRI), we conducted numerical experiments using the model NHM-Chem-Dust installed the stone effect, and we confirmed the improved accuracy (Sekiyama et al. 2023). By an analysis using synoptic observation data, Wu et al. (2023) reported a forecast accuracy would improve by applying the dead vegetation effect into a model in April, when the dust frequency is the highest. Buyantogtokh et al. (2022) developed a method for estimating threshold friction velocity from backscatter coefficients of synthetic aperture radar (SAR).

On the subject (3), observations of PM2.5 etc. were carried out on the roof of ALRC building under ALRC joint research (PI: Prof. Osada, Nagoya Univ.). I instructed a junior high school student in samplings of dry- and wet-deposited substances under the exploration course of JST Junior Doctor Program. She won the top prize at the JST Science Conference.

These works were supported by the Environment Research and Technology Development Fund (JPMEERF20205001), by KAKENHI (22H01310), by International Platform for Dryland Research and Education (IPDRE), and by ALRC joint research.



Dataset of stone distribution in East Asia using a result of Buyantogtokh et al. (2021). This was utilized in a numerical experiment (Sekiyama et al. 2023)

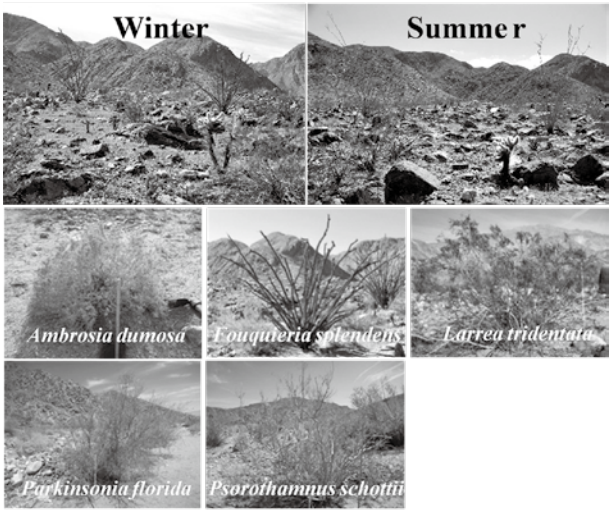
谷口　武士（微生物生態学）

微生物はマイクロレベルの非常に小さい生物であるが、地球上のバイオマスや機能としては非常に大きく、グローバルスケールでの炭素や窒素の動態にも深く関与している。また、植物の定着や土壌の形成に大きな役割を果たす微生物も存在するため、これらの微生物の役割を解明し、乾燥地の環境修復への利用に関する研究を行うことは非常に重要である。このような背景から、微生物生態学分野では、主に乾燥地の環境修復への微生物利用を目指して研究を行っている。また、ミクロスケールからマクロスケールの様々な規模で観察される現象や問題の解明、あるいは解決に向けて、微生物（細菌や菌類など）に着目した研究を行っている。主な研究テーマは下記のとおりである。

・ストレス条件下における植物－微生物共生関係の解明と環境修復への利用
・ストレス条件下で植物に有用な複合微生物系の探索

これらのテーマについて、アメリカ、スーダンを中心に共同研究を行っている。本年度は主に以下の研究で成果を得た。

本年度は、アメリカのコロラド砂漠で生育する植物5種の根の内生微生物に関する研究の再解析を行った。結果として、細菌では冬にグラム陰性の窒素固定細菌が根に増加する一方で、菌類では夏にアーバスキュラー菌根菌が増加することが分かった。このことは、植物に有用な微生物が根で増加すること、そして植物は季節ごとに微生物を使い分けることで適応性を高めている可能性が示された。



Images of winter and summer of the research site located in Colorado desert and five desert plants examined

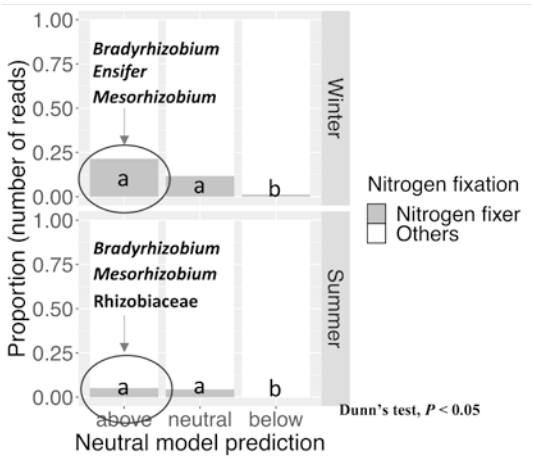
Takeshi Taniguchi (Assoc. Prof., Microbial Ecology)

Microorganisms are micro-level and very small organisms, but the biomass and function on earth is extremely large. Some microorganisms are also very important for ecosystem restoration in arid regions because they have roles for the enhancement of the establishment or stress tolerance of plants and the improvement and stabilization of soil. My laboratory mainly studies about the ecosystem restoration with microorganisms. Also, my laboratory focuses on the various scale of phenomenon and problems in arid region ranged from micro- to macro-scale and aims to revel or solve them via microorganisms such as bacteria and fungi. Followings are the topics of my laboratory.

・Plant-microorganism symbiotic relationship under stressful conditions and the application to ecosystem restoration
・Exploration of useful microbial composition for plants under stressful conditions

These researches are collaboratively conducted with overseas research institutes in the United States and Sudan. In this fiscal year, I obtained results from following researches:

In this fiscal year, reanalysis of research on endophytic microorganisms in the roots of five plant species growing in the Colorado desert of the United States was completed. Results showed that gram-negative nitrogen-fixing bacteria increased in roots in winter, while arbuscular mycorrhizal fungi increased in summer. This indicated that plant-useful microorganisms increase in roots and that plants may increase adaptability for environment by using different beneficial microorganisms in different seasons.



Dominance of nitrogen fixing bacteria in winter

木村　玲二（気象学）

気象学分野では以下のような研究を行っている。

(1) 乾燥地における熱・水収支の定量的解明
(2) 気象データとリモートセンシングデータを併用した干ばつや土地劣化の全球モニタリング
(3) 作物の形態的・生理的な性質に関する情報を得るためのフェノタイピング

これらの研究は、日本学術振興会による科学研究費（代表：19H04239）により中国やモンゴル、全球を対象に行われた。以下に研究結果を示す。

1.　「日本における黄砂観測日数と黄砂発生源の土地被覆との関連性」

中国やモンゴルの乾燥地は、一般的に黄砂の発生源として認識されている。しかし、黄砂の発生は現地の気象条件や地表面状態に左右され、特に発生源における地表面状態が日本の黄砂観測日数とどのように関連しているのか、正確な情報が不足していた。本研究では、2000 年以降の黄砂が発生する春季（3 月～5 月）を対象に、地表面状態（北緯 35 度~50 度、東経 100 度~120 度の範囲）の年々変化を衛星データによって調べた。風の流跡線解析の結果、福岡で観測された黄砂現象のほとんどが、この領域を通過する 3 つのルートをたどっていることが示された。また、日本の黄砂観測日数は 2000 年以降減少傾向にあり、対象領域内における裸地面（または植生面）の面積と強い相関を示した。実際、中国の黄土高原や内モンゴルでは、裸地面積（植生地面積）の減少（増加）が認められている。本研究では、対象エリア内における裸地面積を使った日本の黄砂観測日数を再現する統計モデルも示してあり、裸地面積から春季の黄砂観測日数を前もって見積もることも可能になった。

2.「衛星データを用いた日照時間や降水量の空間分布図の作成」

本研究では、農業気象災害の評価等に資する気候学的指標、すなわち日照時間や降水量に関わると仮定される「衛星曇天率」を提示し、鳥取県において、曇天率と日照時間、降水量との関係を検討した。その結果、曇天率は日照時間や日照率、降水量と高い相関を示すとともに、それらの関係を用いて日照時間と降水量の高解像度空間分布図を作成することが可能になった。将来的には、気象観測所が整備されていない開発途上国に衛星曇天率を適用し、農業気象災害や収量の評価等に役立てたることを考えている。

3.「Aeolian desertification に特化した簡易観測システムの開発」

植生や土壌劣化による Aeolian desertification の観点から、土地劣化のモニタリングに特化した簡易観測システムを試作・開発し、2023 年 3 月にモンゴル・ホルドに設置、観測を開始した。本システムは、飛砂、植生量、地表面湿潤度、景観に関するデータを収集することに特化しており、一般的な気象ステーションとは一線を画している。すなわち、地域的な Aeolian desertification を評価するために、極力気象データを使わずに、将来的な広域モニタリングに適した衛星の利用に発展させることを考えている。

Reiji Kimura (Assoc. Prof., Meteorology)

The Meteorology Subdivision conducts research as follows:

(1) Quantitative analysis of heat and water balances in arid regions.
(2) Global monitoring of drought and land degradation by combining the meteorological and remote sensing data.
(3) Phenotyping to obtain the information regarding the morphological and physiological properties of crops.

These studies are conducting under the aid by Japan Society of the Promotion of Science Grants (KAKENHI 19H04239). I obtained results from following research:

1. Interannual changes of land surface conditions in Asian dust source regions since 2000

The Taklimakan and Gobi deserts and the Loess Plateau in China and Mongolia are generally recognized source areas for Asian dust. However, dust emissions depend on meteorological factors such as air pressure and land surface conditions, and precise information on land surface conditions in the dust source areas and the frequency of dust events in Japan is lacking. In this study, interannual changes of land surface conditions in the springtime since 2000 were examined in a target source region (35°N-50°N, 100°E-120°E). Back trajectory analysis results showed that most dust trajectories of the past 10 years mainly followed three routes passing over this target region. Both the number of Asian dust events observed in Japan and the area with a threshold wind speed Ut of <10 m s^{-1} in the target region significantly decreased after 2000. Further, the area of Ut < 10 m s^{-1} and the number of events were significantly correlated. These results may reflect a decrease in the bare land surface area, which is associated with dust outbreaks.

2. Spatial distributions of sunshine duration and precipitation using the cloudiness ratio calculated by MODIS satellite data

We developed the cloudiness ratio (CR), a climate index calculated using MODIS satellite data considered to be related to sunshine duration and precipitation, and then applied CR in Tottori prefecture during 2000-2019. The CR correlated well with sunshine duration, the percentage of possible sunshine, and precipitation, and displayed both seasonality and regionality. We used these relationships to produce high-resolution (650 m) maps of the spatial distributions of sunshine duration and precipitation.

3. Development of a simple observation system specializing in monitoring of regional aeolian desertification

From the viewpoint of "aeolian desertification" caused by vegetation and soil degradations, we prototyped and developed a simple observation system specialized to monitor the regional land degradation, and applied to the region of Mongolia where is a very sensitive place to the drought and desertification. The observation station at Khuld is located boundary of step and dry step in Mongolia. The data have been taken from 5 March 2023. This system specializes in collecting the data regarding the blown sand, vegetation amount, land surface wetness, and landscape related to the land degradation, which make a clear departure from general weather station. This system aims to use little meteorological data to evaluate these elements regionally, and to apply them to satellite use for the wide area.

寺本　宗正（陸域炭素循環学）

陸域炭素循環学分野では以下の研究を行っている。

1. モンゴルの草原生態系における人為的な攪乱や温暖化が CO_2 の吸収や排出（CO_2 フラックス）におよぼす影響の評価
2. 海浜砂丘生態系における炭素循環に関する研究
3. 長期的な温暖化が土壌有機炭素分解および土壌のメタン吸収におよぼす影響の評価

これらの研究は、科研費（課題番号 20K23365、21H02567、22K12346）、IPDRE シーズ創出研究プロジェクト、鳥取大学乾燥地研究センター共同研究（課題番号 03A2001）、独立行政法人環境再生保全機構・環境研究総合推進費（課題番号 2-2006）の援助を受けて行われている。本年度は、主に下記の点に関して取り組んだ。

1. モンゴルの草原生態系において放牧が土壌呼吸におよぼす影響を評価するため、2022 年 8 月下旬にフスタイ、マンダルゴビ、ブルガンの各草原において、土壌呼吸の観測およびバイオマス調査を実施した。
2. モンゴルの草原生態系（バヤウンジュール）において、季節的な温暖化が植物の生産性におよぼす影響を評価するため、2022 年 8 月上旬に温暖化操作資材および環境観測機器の設置を行った。2022 年度は温暖化操作を開始したばかりであるため、季節的な温暖化が CO_2 フラックスに与える影響は、来年度以降明らかになるものと考えられる。
3. モンゴルの草原生態系（バヤウンジュール）において、小規模の降雨イベント前後の CO_2 フラックスに関する観測を行った。小規模の降雨イベントによって、生態系呼吸速度も光合成速度も大幅に上昇した一方で、それらを差し引いた CO_2 交換には有意な違いが認められなかった。このことから、例え小さな降雨イベントであっても、本草原生態系における CO_2 フラックスの大きな変動要因となることがうかがえた。
4. 乾燥地研究センター敷地内の海浜砂丘における 2020 年（8 月の降水量が著しく少なかった年）の観測データに関して解析を進めた。土壌に由来する CO_2 排出速度（土壌呼吸速度）は基本的に地下 30 cm における温度の季節的な上昇に伴って指数関数的に増加するが、夏季の乾燥ストレスに対する土壌呼吸の応答は周辺の植生状況によって異なることを明らかにした。

Munemasa Teramoto (Assist. Prof., Terrestrial carbon cycle)

The Terrestrial carbon cycle subdivision mainly conducts the following studies.

1. Observation research to evaluate the influence of artificial disturbance and global warming on CO_2 absorption and emission (CO_2 fluxes) in grassland ecosystems in Mongolia.
2. Observation research related to the carbon cycle in a coastal dune ecosystem.
3. Evaluation of the long-term influence of soil warming on the soil organic carbon decomposition and the soil methane (CH_4) absorption.

These studies were supported by Grants-in-aid for Scientific Research (20K23365, 21H02567, 22K12346), the Joint Research Program of Arid Land Research Center, Tottori University (03A2001), IPDRE Research Project, the Development Fund (2-2006) of the Environmental Restoration and Conservation Agency of Japan. In this fiscal year, I mainly worked on the above-mentioned studies as follows.

1. Soil respiration measurement and biomass sampling were conducted in grassland ecosystems in Hustai, Mandalgivi, and Bulgan in late Aug 2022 to examine the influence of grazing on soil respiration in Mongolia.
2. Artificial warming devices (open-top chambers) and environmental measurement systems were set up in a grassland ecosystem in Bayan-Unjuul to examine the influence of seasonal warming on the productivity of the grassland in early Aug in 2022. The warming treatment started this year, and the warming effect on CO_2 fluxes can be examined in the next year.
3. Measurement for CO_2 fluxes before and after the small precipitation event was conducted in a grassland ecosystem in Bayan-Unjuul in early Agu in 2022. The precipitation event remarkably increased both gross primary production and ecosystem respiration, although there was no significant change in CO_2 exchange. This result suggested that precipitation event is one of the strong controlling factors for the temporal dynamics of CO_2 fluxes in this ecosystem.
4. Observation data for soil respiration in 2020 (remarkably little precipitation in Aug) in coastal dunes in ALRC was analyzed. Soil respiration exponentially increased along with the seasonal increase of soil temperature at the depth of 30 cm, but the response to drought stress in summer differed among plots. This result suggested that the response of soil respiration to drought stress varied due to the difference in vegetation around the measurement plot.

Measurement for soil respiration in a grassland ecosystem in Hustai

CO_2 flux measurement in a grassland ecosystem in Bayan-Unjuul

Jiaqi Liu (Specially Appointed Assist. Prof., Environmental Physics)

The Environmental Physics Subdivision conducts research mainly as follows:

(1) Developing a compact measuring device to measure wind-blown sand flux and wind direction.

(2) Evaluating the sand-trapping efficiency of sand fences using a combination of wind-blown sand measurements and UAV photogrammetry at Tottori Sand Dunes.

In this fiscal year, I obtained results from following researches:

1. Wind-blown sand emitted from the coastal sand dunes causes various damages such as to farmlands adjacent to the coast, to human lives and so on. Measures against those damages such as installation of sand fences are required; however, their effectiveness has not been sufficiently clarified due to the difficulties in observations of wind-blown sand flux in the fields. There are some technical limitations of field observation devices: ① measuring wind-blown sand flux at only the fixed direction, ② difficult to measure at multiple points due to high cost, ③ difficult for long-term observation using power supplied from solar panels.

   To solve the above-mentioned problems, I developed an original compact device for wind-blown sand observation in both filed and wind tunnel experiments (Fig. 1). The design of the case of the piezoelectric blown-sand meter mounted on the high-precision ultrasonic sensor can reduce noise and improve accuracy of counting sand particle numbers. It also guarantees maintenance under any harsh environmental conditions. The installation of potentiometer and slip ring makes it possible to simultaneously measure wind-blown sand flux and wind direction, and to supply power from outside to the device. Furthermore, by installing a power control system and a brake mechanism, the operation of this device can be stopped at wind speeds below the threshold wind speed to reduce power consumption. This design allows long-term field observation by using only dry battery. The newly developed device is expected to be flexibly adapted to the needs of various field. The device is now on a patent pending (No. 2022-184512).
2. Fences are commonly used in coastal regions to control wind-blown sand. Sand-trapping fences and sand-stabilizing fences have been installed at the Tottori Sand Dunes, Tottori Prefecture, Japan, to prevent damage by wind-blown sand; however, the effectiveness of these fences has not previously been quantitatively evaluated. This study analyzed the effects of sand fences on sand trapping using field observations of blown-sand flux and unmanned aerial vehicle (UAV) photogrammetry. The estimated total blown-sand flux in the near-ground surface observed inside and outside the sand fences indicated that wind-blown sand was effectively trapped by the sand fences at wind speeds lower than 17 m s^{-1}, reducing sand flux by more than 80%. The UAV photogrammetry results demonstrated that large amounts of sand were transported from the dune to the fenced area during March and April, and sand initially accumulated on the lee side of the sand-trapping fences, forming a new foredune. Sand accumulated on the existing foredune during April and May, and the vertical accretion around the foredune was two to four times the sand deposition within the sand-stabilizing fences. This indicated the effectiveness of sand-trapping fences for controlling wind-blown sand; however, their efficiency was reduced as they were gradually buried, with sand being trapped by the sand-stabilizing fences.

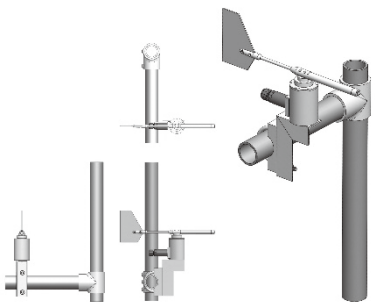


Fig. 1 Photo of the wind-blown sand detection device

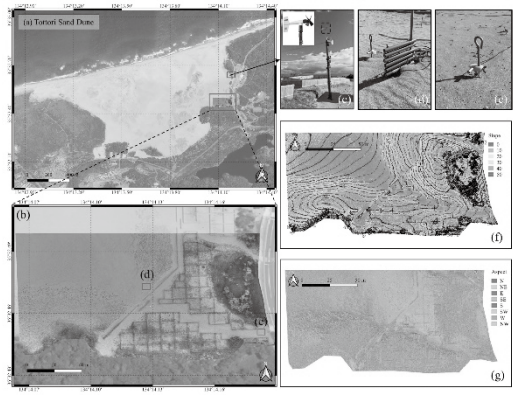


Fig. 2 Location maps of (a) the Tottori Sand Dunes, (b) the area of the UAV survey and piezoelectric blown-sand meters on (d) the seaward side and (e) the landward side of the sand fences, and (c) the anemometer. The (f) slope and (g) aspect is based on the UAV survey conducted on 11 March 2021.

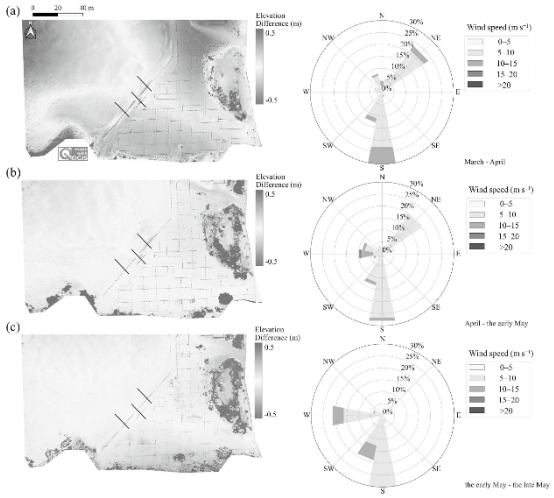


Fig. 3 Elevation changes in the study area and wind distribution for (a) March to April, (b) April to early May, and (c) early to late May. Positive values indicate deposition of sand; negative values indicate erosion.

Ping Pui (Joseph) Ching (Specially Appointed Assistant Professor)

In this fiscal year (FY2022), I have been working on regional meteorological-chemistry model simulations using the model NHM-Chem developed by the Meteorological Research Institute (MRI) under the Japan Meteorological Research Agency (JMA) to study the impact of aerosol particles on air quality and public health in East Asia, with a special focus on desert dust season in the Springtime. A research proposal about this topic submitted to Kiban-C managed by the Japan Society for the Promotion of Science (JSPS) was awarded research funding for three years. The research is undergoing and a brief introduction of the research project is given below.

Research motivation

Aerosol particles or PM, deteriorate air quality and have been linked to high incidence of cardiovascular diseases, lung cancer and stroke. Many previous studies pointed out that aerosol mixing state affects (1) particle deposition efficiency in human lung; (2) particle toxicities; and (3) particle interactions with human cells and tissues. This research project is to study the mixing state of aerosol particles, including desert mineral dust particles, in East Asia and how the mixing state of aerosol affect the air quality.

Focus on East Asia

We focus on East Asia because (1) it is a complex aerosol environment characterized by aeolian dust from deserts in China, black carbon, inorganics and organics emissions from urbanized and industrialized cities and sea salt particles over the regional; (2) East Asia is a highly populated (about 1.7 billion and >20% of the total world population) and economically rapidly developing region. From World Health Organization (WHO), 2.2 million premature death was caused by air pollution in Asia Pacific in 2016.

Key research questions

We aim to examine three research questions: (1) What is the spatio-temporal distribution of mineral dust particle in East Asia? (2) How do mineral dust particles mix with other aerosol types in East Asia? (3) What is the relationship between spatio-temporal distributions of mixed and pure mineral dust particles and public health?

3) 乾燥地農業領域
辻本　壽（分子育種学）

乾燥および高温環境に適応できるコムギ品種を育種することは、気候変動時代において、世界の食糧生産の安全保障のための重要な解決策のひとつである。私たちは、利用できる遺伝資源の範囲を広げて、強力かつ迅速に育種することを目的に研究している。そのため、①野生種の種内変異を実用コムギ品種へ移行した多様性系統群の育成、②実際のストレス圃場での乾燥・高温耐性の評価、③ゲノムを網羅した多数の DNA マーカーを用いた多様性系統群の遺伝子型解析（ジェノタイピング）、④耐性に関与する遺伝子座の同定およびマーカー選抜育種への適用を行っている。

これまで、様々な自生地から集められた 43 系統のタルホコムギ (*Aegilops tauschii*) の遺伝子をパンコムギの実用品種に導入した系統群を作り、スーダン農業研究機構との共同研究によって、同機構の複数の試験場で栽培し、高温および乾燥耐性を評価した。また、DNA 多型情報を利用して、パンコムギの D ゲノムに高温および乾燥耐性の遺伝子座を同定した。

本年度は、A ゲノムおよび B ゲノムにおいて、耐性遺伝子を見いだすために、9 系統の野生 4 倍性コムギ (*Triticum dicoccoides*) の遺伝子を栽培 4 倍性コムギ (*T. turgidum*) に導入した系統群を開発した。これらをジェノタイピングするとともに、スーダンで耐性を評価し、A および B ゲノムにも耐性遺伝子座を同定することができた。これら、A、B、D ゲノムの遺伝子座を集積させ、強い耐性をもたせるため、耐性を示す 6 倍性および 4 倍性コムギを交配し、5 倍性コムギを作成し、耐性遺伝子の相加効果を調査している。

乾燥・高温耐性は多数の遺伝子が制御する量的形質であり、またパンコムギの遺伝子プールに強い効力の遺伝子座が見られなかったが、私たちの研究ではそれらを見いだし、これらの耐性形質についても、マーカー選抜育種の可能性を示す事ができた。

Diversity of shape among some multiple derivative lines showing spike length variation. Balla et al. (2022) Theoretical and Applied Genetics 135:1671-1684

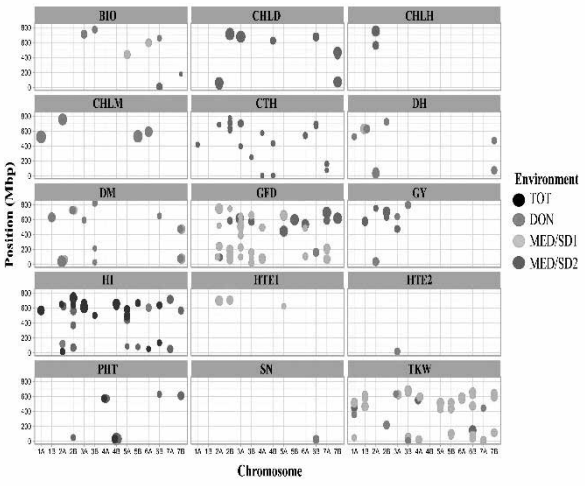
3) Division of Dryland Agriculture
Hisashi Tsujimoto (Prof., Molecular Breeding)

Breeding wheat varieties that can adapt to dry and hot environments is one of the key solutions for securing global food production in an era of climate change. Our research aims to achieve this goal by expanding the range of genetic resources and accelerating breeding techniques. To this end, we are (1) breeding diversity lines that carry intraspecific variation from wild species in practical wheat varieties, (2) evaluating drought and high-temperature tolerance in actual stress fields, (3) genotyping diversity lines using multiple DNA markers covering the genomes, and (4) identifying loci involved in tolerance and markers and applying the results to marker-assisted selection.

To date, the genes of 43 goat grass (*Aegilops tauschii*) lines collected from different indigenous areas have been introgressed into practical bread wheat cultivars and, in collaboration with the Sudan Agricultural Research Corporation, the lines were grown in several test fields and evaluated for high-temperature and drought tolerance. Using DNA polymorphism information, loci for high-temperature and drought tolerance were identified in the D genome of bread wheat.

This year, nine wild tetraploid wheat (*Triticum dicoccoides*) lines were introduced into cultivated tetraploid wheat (*T. turgidum*) to find tolerance loci in the A and B genomes. These were genotyped and evaluated in the test field in Sudan, and tolerant loci were also identified in the A and B genomes. To accumulate these loci in the A, B, and D genomes and to develop strong resistance, pentaploid wheat lines were created by crossing resistant hexaploid and tetraploid wheat lines. These lines will reveal the additive effect of the tolerant genes.

Although drought and high-temperature tolerance are quantitative traits controlled by a large number of genes, and no loci of strong effect were found in the bread wheat gene pool, our research has identified them and shown the potential for marker-assisted selection breeding for these tolerance traits as well.



Physical positions of markers associated with evaluated traits in the four environments; Tottori (TOT); Dongola (DON); Wad Medani first sowing date (MED/SD1); and Wad Medani second sowing date (MED/SD1). Symbol size corresponds to the allelic effect of each marker-trait association. Balla et al. (2022) Frontiers in Plant Science. (2022) 13:895742

藤巻　晴行（灌漑排水学）

灌漑排水分野では、乾燥地・半乾燥地における節水灌漑およびウォーターハーベスティングと灌漑に伴う塩類集積対策の研究に取り組んでいる。昨年度は、主として以下の研究に取り組んだ。

1. IPDRE プロジェクト予算による「植物の生長モデルと天気予報を用いた灌漑水量の決定」に関する研究。乾燥地研究センター圃場でそれぞれ緑豆とブロッコリーを供試作物として、モロッコで供試作物とする灌漑実験を行った。
2. JSPS 国際共同研究加速基金「土壌塩分輸送シミュレーションモデルを用いた除塩用水量の最適化」に関する研究。ウズベキスタンのアラル海流域イノベーションセンターで 6 月から 10 月にかけてゴマを供試作物として、また、11 月から 3 月にかけて石垣島の国際農林水産業研究センター熱帯・島嶼研究拠点のビニールハウスでミニトマトを供試作物として行った。
3. 博士研究「ビニールシートと貯水槽を用いたウォーターハーベスティングにおける栽培面積の最適化」の実験をセンター内砂丘圃場で実施した。
4. IPDRE プロジェクト予算による「パレスチナ西岸地区におけるウォーターハーベスティングによる食料安全保障の強化」。ラマラ市郊外の傾斜地でビニールシートと貯水槽を用いたウォーターハーベスティングシステムを設置し、自動灌漑栽培実験を行った。
5. SATREPS プロジェクト「アラル海地域における水利用効率と塩害の制御に向けた気候にレジリエントな革新的技術開発」の国内での研究活動として、ポット実験によるゴマの耐塩性評価実験を行った。

An irrigation experiment using broccoli in ALRC

An irrigation experiment using sesame in IICAS

Haruyuki Fujimaki (Prof., Irrigation and Drainage)

The subdivision of irrigation and drainage in dryland studies on water-saving irrigation, water haevesting and salinity management associated with irrigation. I carried out following research activities last year:

1. Determination of irrigation depths using a numerical model and quantitative weather forecast as an activity of an IPDRE project in ALRC (using mungbean and broccoli) and Morocco (using fababean).
2. Determination of irrigation/leaching depth using a numerical simulation model of salt movement, funded by JSPS "Fostering Joint International Research (B)". We performed experiments using sesame in International Innovation Center for Aral Sea Basin and tomato in Ishigaki Island (JIRCAS).
3. An experiment in ALRC as a phD study for the "Optimization of cultivated area in a water harvesting system with a plastic sheet and a tank in a sandy field". An experiment for water harvesting system with a plastic sheet and a tank in ALRC
4. "Enhancing Food Security using water harvesting in West Bank of Palestine" as an activity of an IPDRE project. Experiments of water harvesting system using a plastic sheet and reservoir in a slope in suburb of Ramallah was carried out
5. .

Water harvesting system in ALRC

An irrigation experiment using tomato in Ishigaki Island.

安 萍（植物生理生態学）

植物生理生態学分野では、乾燥地における植物や作物の生理生態学と適正栽培技術の開発を中心的課題としている。特に、植物と作物の環境ストレス応答とその耐性機構の解明、乾燥地農業における水利用効率向上技術の開発、作物の塩および乾燥ストレス緩和技術の開発などに力を入れている。これらの研究は国内における基礎研究と国外での乾燥地の現場における応用研究を組み合わせた研究を進めている。また，砂漠と砂漠化地域において植物の分布と土壌環境を調査し、分布の特性から植物と土壌との相関関係を解明する研究も重点的に取り組んでいる。この研究は、砂漠及び砂漠化地域の植生回復に相応しい緑化用樹種・草種の選定、栽培方法の確立などの策定に役立ち、さらに、生態系の環境維持に重要な役割を果たす植物や経済的に価値の高い植物を発見した場合、これらの植物の生態生理特性を解明し、農業利用に適切な栽培技術を開発している。具体的には、以下の課題について進めている。

1. コムギ、ホウレンソウおよび塩生植物 Suaeda salsa の耐塩性機構の解明。
2. 作物の根の特性と環境ストレス耐性との関係の解明。
3. 経済価値の高い塩生植物の栽培技術開発。
4. 中国の砂漠と砂漠化地域における植物の分布調査。
5. 根の細胞壁の化学性・物理性と植物の耐塩性の関係の解明。

本年度、中国科学院植物研究所および遺伝と発育生物学研究所農業資源研究センターの研究者と連絡をとり、共同研究として中国渤海湾周辺の塩類集積土壌における植生の生理生態調査、塩生植物栽培実験の結果およびムウス砂地植物調査などについて検討し、論文作成についても助言した。また、同センターが行っている塩類集積土壌での緑化プロジェクトの問題について解決策および共同研究の進み方を検討した。COSMAT University Islamabad と University of Calar との共同研究を推進し、随時研究結果などについて検討した。根細胞壁の化学性・物理性と植物の耐塩性の関係の解明について、本年度コムギ実験に引き続きホウレンソウと *Suaeda salsa* に関しても実験を行った。

下の写真に研究成果および現地調査の様子を示した。

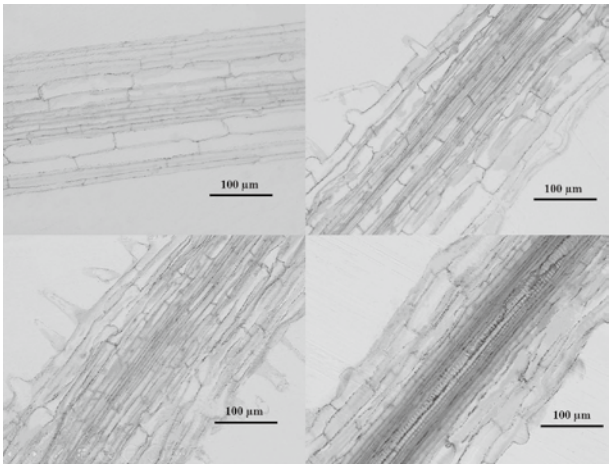


Figure Ruthenium red stained sections of pectin location in spinach roots under 0 (a), 100 (b), 200(c) and 300 (d) NaCl treatments. Scale Bar ＝ 100 µm.

Ping An (Assoc. Prof., Plant Eco-physiology)

The Plant Eco-physiology Subdivision conducts researches on the elucidation of eco-physiological characteristics of plants and crops and development of appropriate cultivation technology in arid lands. Particular efforts are being made to clarify the responses of plants and crops to environmental stresses and relevant mechanisms. The purpose of the studies is to develop cultivation technology for enhancement of water use efficiency and mitigation of drought and salinity stresses in dryland agriculture. The studies combined the basic research in Japan using the ALRC's facilities and applied research at real fields in drylands. Besides, plants distributions in deserts and desertified areas are also the focus of the studies. By knowing the interactions of plants and environmental conditions, measures for vegetation recovery in desertified areas would be established. Special plants that have important ecological functions or potentially economic value would be further investigated. The current studies are:

1. Salt tolerance mechanisms in wheat spinach and halophytes;
2. Relationship between root and plant stresses tolerance;
3. Development of cultivation technics of halophytes with high economic value;
4. Vegetation distribution in the desertified areas of China;
5. Physio-biochemical characterization of root cell wall in salinity tolerance in plants.

The main research activities during the fiscal year 2022 include an academic information exchange with the researchers of Institute of Botany and Center for Agricultural Resources Research of the Chinese Academy of Science (CAS). Results of the field investigation of the ecology and physiology of halophytes around Bohai Bay and Mu Us sandy land and halophytes cultivation experiments were discussed and paper writing were conducted. Cooperation on a greening project in saline soils was pushed forwarded. Joint research with COSMAT University Islamabd and University of Calar were conducted and results of the experiments were discussed. Studies on the physio-biochemical characterization of root cell wall in plant salt tolerance were continually carried out.

Field investigation in Mu Us sandy land, Inner Mongolia, China.

石井　孝佳（植物細胞遺伝学）

植物細胞遺伝学分野では以下のような研究を行っている。

(1) ササゲの遺伝子改変による半数体誘導系統の作成
(2) コムギ新奇遺伝資源の創出
(3) 異種間交雑で起こる染色体脱落現象の解明
(4) イネ科亜科間雑種の創出と解析
(5) BNI コムギのインドへの導入

これらの研究は、クイーンズランド大学（アンナ・コルツノフ）らを含む世界中の 6 箇所の研究機関と多国籍の種子会社、CIMMYT と神戸大学（松岡由浩）、スーダン ARC（遺伝資源バンク）、日本大学（飛田哲）、東京都立大学（岡本龍史）との共同研究で行われている。

本年度は、特に以下の研究で成果を得た。

1. ササゲは乾燥地域で栽培され食されており、乾燥地の食料安全において非常に重要なマメ科作物です。また、ササゲはこれまで研究があまり行われてこなかった無視作物でもあります。植物を改良するためには長い年月が必要です。本論文ではササゲの迅速栽培法を開発しました。1 年間に 8 世代のサイクルを可能にしました。開発した方法は胚培養やその他高度な技術、高価な機材を必要とせず、受精後 11 日の未熟な鞘を 39℃の高温状態で 2 日間乾燥させることで達成する事ができました。よって、本方法はササゲの改良のための基盤技術を提供する発見となりました（図 1）。
2. 主要作物であるコムギとイネは、異なる亜科に属しており、通常は交雑できません。よって、両種の持つ優良遺伝資源を相互に利用することは不可能でです。東京都立大学と本センターの共同研究により、コムギ - イネ、コムギ - トウモロコシ、コムギ - パールミレット間の交雑不全を乗り越え、世界で初めて交雑植物の（イネコムギ、トウモロコシコムギ、パールミレットコムギ）作出に成功しました。顕微授精により単離した卵細胞と精細胞を融合させ、イネコムギ、トウモロコシコムギ、パールミレットコムギ受精卵を作成し培養した後、植物体へと生育させました（図 2）。科内の細胞融合、受精卵から作成された雑種個体は既存の法律では屋外での通常栽培が可能であり、社会実装への障壁はないです。これらの雑種植物は乾燥地研究センターの圃場で農業形質の調査が現在行われています。

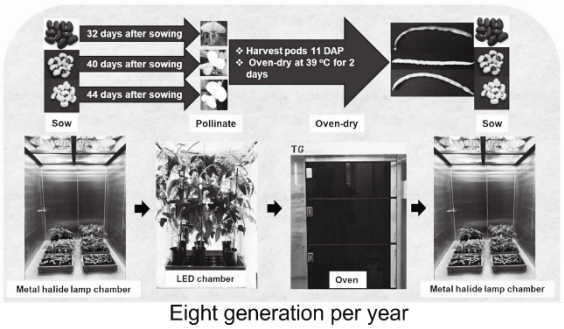


Fig.1 Cowpea speed breeding method allows us to have eight generations per year.

Takayoshi Ishii (Assoc. Prof., Plant Cytogenetics)

The Plant Cytogenetics Subdivision conducts research mainly as follows:

(1) Generation of haploid inducer lines with modification of CENH3 gene of cowpea
(2) Creation of novel genetic resources for wheat
(3) Chromosome elimination research
(4) Hybrid production with subfamily distant grass species
(5) BNI wheat for India

The international collaboration project was made possible through a grant to The University of Queensland (Australia) by the Bill & Melinda Gates Foundation (USA). International 6 research center or university and seed company is participating in this project. JST SATREPS funding through Satoshi Tobita (Japan). JSPS funding through Yoshihiro Matsuoka (Japan) and Takashi Okamoto (Japan).

I obtained results from the following research:

1. Cowpea is a legume crop of great importance for food security especially in arid regions. Cowpea is also a neglected crop that has not been well researched. It has taken many years to improve the crop. In this work, a method for speed breeding of cowpea was developed, allowing a cycle of eight generations per one year. The method developed did not require embryo culture or other advanced techniques and expensive equipment. This method could be achieved by drying immature pods (11 days after pollination) for two days at 39°C. Thus, this method will be the basic technology for cowpea improvement (Figure 1).
2. The major crops, wheat and rice, belong to different subfamilies and cannot normally cross. It is impossible to mutually exploit the superior genetic resources of both species so far. Through joint research between Tokyo Metropolitan University and ALRC, we have overcome the hybridization barriers between wheat-rice, wheat-maize and wheat-pearl millet, and succeeded in producing the world's first hybrid plants (rice-wheat, maize-wheat and pearl millet-wheat) (Figure 2). Fertilized eggs of rice-wheat, maize-wheat and pearl millet-wheat were produced by fusing egg and sperm cells isolated by in vitro fertilization method. Hybrid plants produced from intra-family cell fusions normally be grown outdoors under existing legislation and there are no barriers to social implementation. These hybrids were currently being evaluated for agronomic traits in the fields of the ALRC.

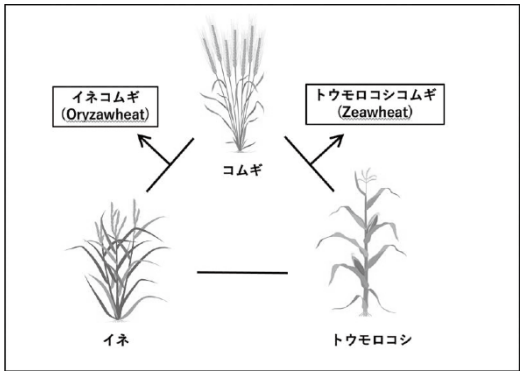


Fig.2 Hybrid production via in vitro fertilization (IVF) method in grass species.

山崎　裕司（分子育種学）

分子育種学分野では以下のような研究を行っている。

(1) リン欠乏土壌に耐性を有するコムギ系統の開発、及び遺伝子特定
(2) 乾燥地における非生物学ストレス、特に耐暑性、耐乾性を有するコムギ系統の構築
(3) 屋外圃場生育のキャノピー温度と収量の相関関係に関する研究
(4) 乾燥ストレスのゲノム選抜におけるダイズの炭素同位体比分析
(5) 乾燥ストレス耐性選抜に向けたホップ育種に関する研究

SATREPS、CREST などの援助および企業との共同研究によって行われている。

本年度は、特に以下の研究で成果を得た。

1. 前年度までに、未利用遺伝資源を含んだコムギのリン欠乏耐性を有する系統には、過剰な光エネルギーの侵入を防ぐ制御や、光合成に必要な最低限のリンの量がコントロール系統より低いことが示唆されたが、その祖先系統である合成コムギも似たような性質があったが、遺伝的解析での親との推定に若干のズレを確認した。 (Figure 1) 。
2. 鳥取大学乾燥地研究センター内の人工気象器内において、日本のコムギ栽培品種である農林 61 号に、様々な生育ステージの高温に焦点をあて、得られた種子の高温発芽能力を調べたところ、種子形成期に高温に曝された系統が有意に高かった。その結果を種子のメタボロームを用いて原因を網羅解析し、原因物質候補を特定した (Figure 2)。
3. 昨年から引き続き、スーダン・ワドメダニの灌漑圃場に於いて栽培試験から得られた RILs 系統の種子を用いて、炭素同位体比解析を行い、キャノピー温度に関連するとされる気孔開閉度を予測した。
4. 200 系統のダイズコアコレクションを鳥取大学乾燥地研究センターの圃場および筑波大学に於いて栽培試験を行い、その葉内に含まれる炭素同位体比解析により、気孔の開閉を推定し、予測モデルに当てはめた。
5. ストレス耐性ホップ育種目的として、気孔コンダクタンス測定・気孔数の測定を行い、同解析手法が育種選抜の手法として確立する新手法としてメタボロ解析や気孔撮影などの導入を検討した。

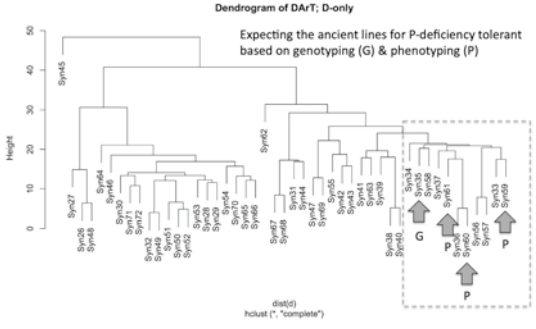


Figure 1. Dendrogram of Syn wheats for P-deficiency tolerance

Yuji Yamasaki (Special appointed assistant professor, Molecular Breeding)

The molecular breeding lab team currently working on the following research topics:

(1) Development of phosphorus deficiency tolerant wheat through identification of genes contributing this tolerance
(2) Development of tolerant wheat lines under abiotic stresses especially dehydration and heat stress as main stresses of arid-land area
(3) Study on correlation between canopy temperature and yield of field growth
(4) Genomic selection for drought tolerance in soybean using carbon isotope ratio analysis
(5) Screening method for abiotic stress tolerance on beer hops

These studies are conducting under supports from SATREPS, CREST and joint-research program with a private company mainly.

The following things are my projects in the fiscal year 2022 (Apr-June).

1. In the last FY, we found that selected tolerant lines with high phosphorus use efficiency have ability to prevent excess photoenergy into photosynthesis and lower level of minimum phosphate requirement for photosynthesis in the tolerant lines. In the FY, we confirmed some discrepancy between genotyping and phenotyping analysis (Figure 1).
2. Norin 61 (Japanese popular cultivar) was heat treated in different stages in growth chamber at the Arid Land Research Center, Tottori University. Germination tests with these seeds revealed that seeds in heat stress during seed development had higher germination ability under heat stress. Metabolome analysis suggested that some of metabolome especially hormone balance may contribute heat germination ability (Figure 2).
3. The analysis of field test results showed that there was a correlation between canopy temperature and yield in wheat populations derived from a specific line. Seeds from field examination at Wad Medani, Sudan were examined for IR-MS analysis to estimate stomata closure relating to canopy temperature.
4. Soybean core collection were field evaluated under drought environments at Tottori and Tsukuba universities. These plants were analyzed in IR-MS to estimate stomatal open/closure and to use for prediction model.
5. To perform breeding hops for selection of stress tolerance, IR-MS analysis, stomatal conductance and stomatal numbers were performed and confirmed to be useful methods (such as metabolome) for the selection.

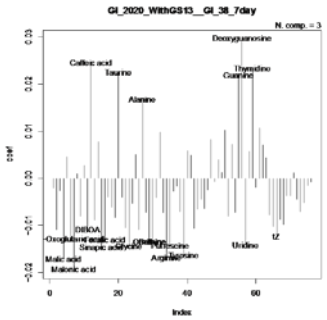


Figure 2. Possible metabolites for heat germination ability

(3) 外国人研究員 / Foreign Research Scholars

Benjamin Ewa Ubi (Visiting Professor, Division of Agricultural Production)

Our research activities focused on these two main aspects, (1) Establishing a non-destructive evaluation method for root zone elongation of cowpea (*Vigna unguiculata* L. Walp) in Tottori sandy field, and (2) Developing a protocol for efficient genome editing in cowpea (*V. unguiculata* L. Walp.)

Cowpea is a grain legume of major importance for global food security especially in the developing countries; and serves as an inexpensive source of plant-based protein for human nutrition and health. Although a resilient crop, cowpea production seriously suffers from abiotic production constraints such as heat, drought, and salinity; and global efforts are being made to search for cowpea genetic resources with adaptive traits such as improved root systems underlying enhanced crop productivity and adaptation especially in the rapidly expanding drylands of developing countries under the increasing climate change scenario. In the course of our research, a simple non-destructive *in situ* method was established involving surface application of a herbicide, to screen genotypes on the basis of their differences in root zone expansion. A vertical, rather than a horizontal mobility of the herbicide was confirmed in this study. The unique nature of the sandy experimental field at the Arid Land Research Centre (ALRC), Totorri, being relatively homogenous throughout the root zone, accounted for the success of this protocol, which need to be validated in different environments and soil types to enhance efforts at field-based root zone elongation phenotyping in the future.

Genome editing, based on the use of site-specific nucleases (SSNs; most especially Clustered regularly-interspaced short palindromic repeats/CRISPR associated protein 9, CRISPR/Cas9), to precisely introduce mutations in targeted sites of a species genome with high fidelity has become a revolutionary genetic technology. Thanks to the availability of sequence information of genes, a floodgate has been opened on the limitless opportunities offered by this innovative technology for diverse applications including molecular plant breeding. Our research team at the ALRC has been working towards establishing an efficient protocol for genome editing of cowpea, an “orphan” crop mainly grown in developing countries, based on the CRISPR/Cas-9 system. As an important first step, a regeneration protocol to induce multiple shooting in *in vitro* cultured explants has been established (Fig. 1) and efforts are now underway to implement the genome editing protocol *in planta*.

A

B

C

Fig. 1: A: 4-day old cultured isolated cowpea embryonic axes (EAs) with intact plumule growing in shoot induction media (SIM); B: 20-day old plantlets with induced multiple shoots after the shoot apical meristem (SAM) was excised with scissors when the cultures were 5 days old; C: 55-day old plantlets with multiple shoot formation after subculturing in root induction media (RIM) ready for acclimatization/transfer to pots in the screenhouse. This simple multi-shoot induction procedure is pivotal to efficient genome editing *in planta*.

Izzat S. A. Tahir (Visiting Professor, Molecular Breeding)
October 2022-September 2023

Integrated approach for breeding climate-smart wheat varieties for dry and heat-prone environments

To keep pace with the continuously growing demand for more wheat in an environmentally and socially sustainable manner, agriculture has to face an extraordinary challenge. To cope with this challenge, wheat yield should increase by 1.7% per year over the next 30 years worldwide while the current yield increase is only 0.9% per year. The main strategy to ensure that progress toward supply goals and climate change adaptation should be built on a better understanding of wheat response to the hot and fluctuating environment. Future wheat variety development should consider a more precise strategy based on a thorough understanding of the genetic makeup of the new varieties as well as their interaction with the fluctuating environmental conditions. Therefore, new resources and innovative methods are needed to deliver improved varieties within shorter selection cycles.

1- Assessment of Genotype x Environment x management (G x E x M) interaction in wheat: To clearly understand the nature of G x E x M interaction, accumulated phenotypic data of a set of 20 Sudanese cultivars from more than 30 environments (combinations of season, location, and sowing dates) along with the climatic data are being analyzed. As shown in Figure 1, the results are expected to lead to new recommendations for wheat sowing dates in Sudan based on the cultivar, location and their interaction with the management.

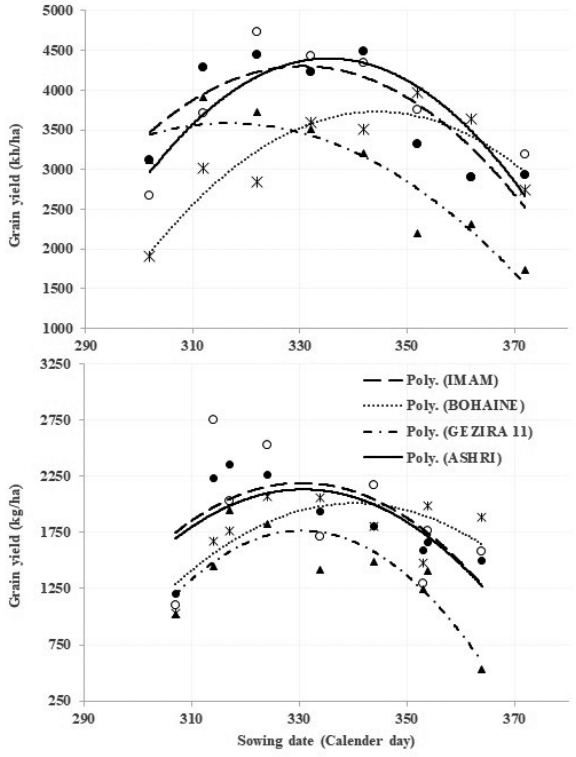


Figure 1. Interactive effects of genotype, environment (location) and management (sowing date) on the grain yield of wheat varieties grown in dry and hot environments at (a) Wad Medani, (b) New Halfa, Sudan, during 2019-2022.

2- GWAS for grain shattering in the dry, hot, irrigated environments

Although grain shattering is genetically controlled, strong interactions exist with environmental factors such as heat, wind speed and dry weather conditions. Depending on the genotype and weather conditions, delayed harvesting causes severe losses in the yield of wheat varieties with high grain shattering tendency (Figure 2). Clarifying the mechanisms behind the genetic differences in grain shattering, identifying molecular markers and developing non-shattering cultivars are urgently needed. Therefore, 250 genotyped wheat lines were phenotyped in two field trials in Sudan and in the glasshouse at ALRC. Data on grain shattering, spike morphology and seed characteristics were scored and genome wide association study (GWAS) analysis is underway.

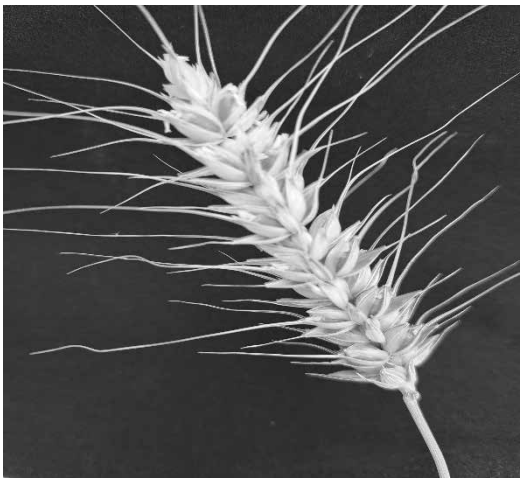


Figure 2. Wheat spike showing high degree of grain shattering characteristics after maturity

3- Distinctness, Uniformity and Stability (DUS) tests for the released bread wheat cultivars in Sudan

DUS tests are carried out to ensure that a new variety is distinct from existing varieties, its characteristics are uniform, and the variety is stable with consistent phenotypic characteristics from one generation to the next. A series of experiments were conducted in Sudan for the DUS test followed by detailed analysis at ALRC for the morphological and molecular characterization. All results will be combined in a catalogue to be available for all users including seed producers and inspectors.

4- Advancement of segregating populations

A total of 14 segregating populations (each consisted of about 165 lines) were selected based on their characteristics for heat stress tolerance, introgression of useful traits from wheat wild relatives (Aegilops tauschii) and other climate-smart traits. Most of the selected populations were derived from crossing and backcrossing of heat tolerant wheat varieties with multiple synthetic derivatives (MSD) lines. These populations have been advanced to next generation using the facility of speed breeding. The process will continue until uniform and homogeneous recombinant inbred lines are obtained.

Levent Şaylan (Visiting Prof. Dr. at ALRC)

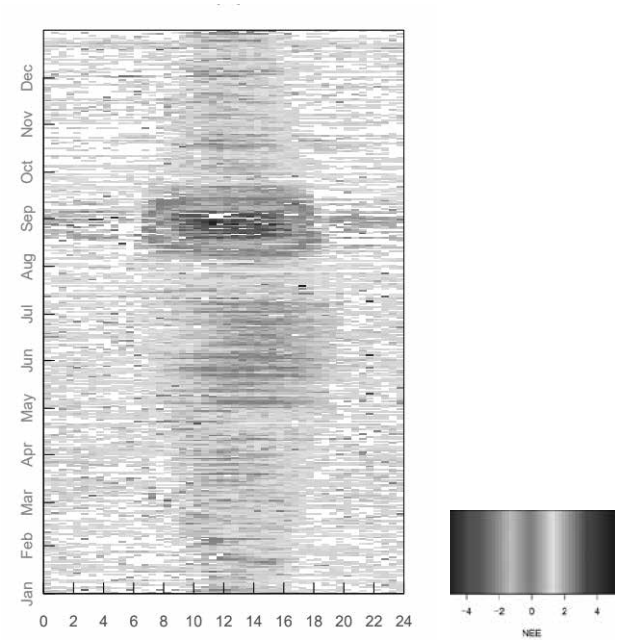
I carried out the following research activities between April 2022 and March 2023. I started working for ALRC on November 1, 2022. Therefore, the following includes outlines of research conducted and currently conducted by me (between April 2022 and March 2023) at both the Arid Land Research Center and Istanbul Technical University.

1. I conducted research on determining the risks arising from future climate change for plants at some locations in Türkiye. I submitted the report on this to the relevant institution.
2. The research continues determining and modelling the evaporation occurring in the Lake Egirdir in the Central Anatolia Region using a micrometeorological approach. The collected data will be analyzed after November 2023, and the final report will be submitted to the relevant institution in February 2024.
3. My CO_2/H_2O measurements continue by the Eddy Covariance method on the alfalfa plant at Atatürk Soil Water and Agricultural Meteorology Research Institute, Kırklareli, Türkiye. In January 2024, all collected data will be analyzed and a manuscript is planned to be prepared and submitted to an international journal.
4. The results of our applied study on the albedo of some crops and their changes were published in an international journal.
5. The results about the estimation of daily net ecosystem exchange values using machine learning based on our measurement and analysis of CO_2 fluxes of winter wheat is published in an international journal.
6. Analysis of meteorological data measured in the Desert steppe ecosystem in Mongolia;
7. Analysis of CO_2 flux data measured by the micrometeorological (Eddy Covariance) method in Mongolia (Tsogt-Ovoo);
8. Determination of energy fluxes in the desert shrubland ecosystem in Mongolia (Tsogt-Ovoo);
9. Modeling of net ecosystem exchange (NEE) of shrub ecosystem.
10. Improvement of our understanding on temporal behavior and causes of the carbon source /sink of desert shrubland ecosystem.

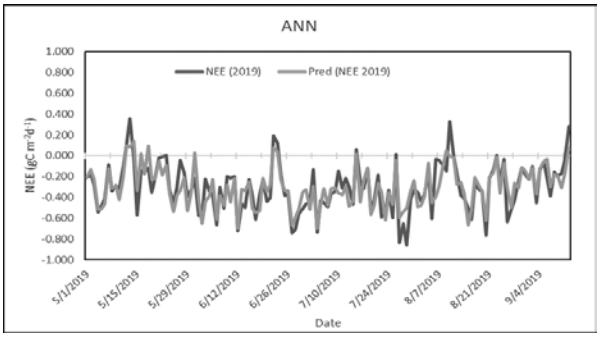
The following covers outlines of my research activities at ALRC (during my visiting period) from November 1, 2022 to March 30, 2023.

During this period, I studied on the topics of ``Analysis and Comparison of Carbon dioxide Exchanges over Desert Ecosystems in Mongolia`` and obtained following results:

1. I made a poster presentation containing some examples of micrometeorological research in my country at the workshop held at ALRC in November 2022.
2. I have analyzed the collected meteorological and micrometeorological data from Tsogt-Ovoo, Mongolia in order to estimate CO_2 and energy fluxes over shrub desert ecosystem for different rainy growing seasons (wet and dry). Some of the results were presented in the Japan Geoscience Union Meeting (JpGU) 2023.
3. I have analyzed energy balance components and their temporal variations and their influence on net ecosystem exchange. Additionally, remote sensing data is used to simulate net ecosystem exchange of vegetation. I started preparing a manuscript on the CO_2 exchange over shrub steppe ecosystem and the factors affecting net ecosystem exchange for wet and dry periods. It has been determined that the carbon exchange in the desert ecosystem varies significantly from year to year and this change is not only affected by the meteorological factors taken into account only during the development period.
5. In addition to this, I am preparing a manuscript on the modeling of some micrometeorological features (other than NEE) of the desert ecosystem.
6. I analyze the changes of CO_2 and H_2O fluxes in the shrubland ecosystem during the non-growing season. I am planning to prepare a manuscript on the results of this study.



Variation of net ecosystem exchange (as an example from the desert)



Time series of measured and modeled NEE (presented in JpGU meeting)

Mulatu Liyew Berihun (Visiting Associate Professor, Integrated Desertification Control)

The division of Integrated Desertification Control conducts research mainly as follows:

(1) Predicting runoff and sediment responses to climate-resilient land use and management scenarios

Soil erosion is the predominant agent affecting ecosystem services in the Ethiopian highlands. However, land management interventions aimed at controlling erosion in the region are hampered, mainly by a lack of watershed-based appropriate management practices and anticipated climate changes. This study examined the effectiveness of different land use changes and management scenarios in decreasing runoff and sediment loss under current and future climates in the drought-prone humid watershed of the Ethiopian highlands. We employed a modeling approach integrating observed data at watershed and plot scales with Soil and Water Assessment Tool (SWAT). In the first step, we evaluated the impact of land use changes between 2006 and 2017 on runoff and sediment loss. Then, we developed five land use and management scenarios based on watershed land capabilities and selected land management practices. Model parameters were modified based on runoff and sediment loss results obtained from experimental plots of biophysical and agronomical land management practices in the watershed. The runoff and sediment loss were simulated under current (2014 - 2019) and future climates (the 2050s) for each land use and management scenario.

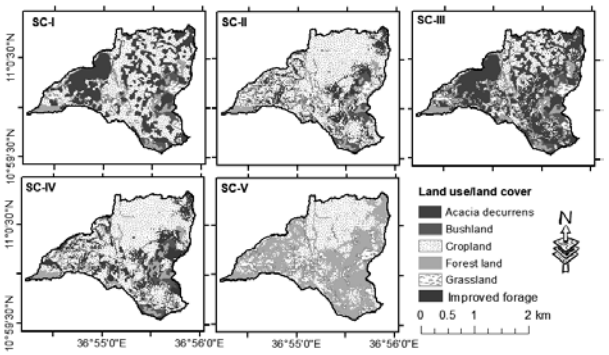


Fig. 1. Maps of proposed alternative land use change scenarios in the Kasiry watershed. We used the 2020 LULC map for SC-I to represent the existing land use types.

Results revealed that land use changes (mainly an increase in *acacia dcurrens* plantations by 206%) alone between 2006 and 2017 reduced runoff by 31% and sediment loss by 45%. Under the current climate, the five-land use and management scenarios reduced runoff by 71 - 95% and sediment loss by 75 - 96% compared to the baseline scenario. Under the future climate (2050s), these scenarios decreased runoff by 48 - 90% and sediment loss by 54 - 91%. However, their effectiveness was slightly decreased (5 - 23%) because of increases in rainfall (10 - 46%) and mean temperature (1.7 - 1.9°C) in the 2050s. The scenario of improving vegetation cover through forage Fig. 2. Spatial distributions of SL severity for the different combined land use change and land management scenarios.

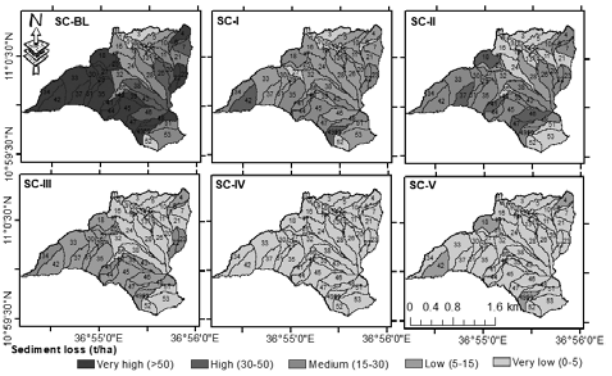


Fig. 2. Spatial distributions of SL severity for the different combined land use change and land management scenarios.

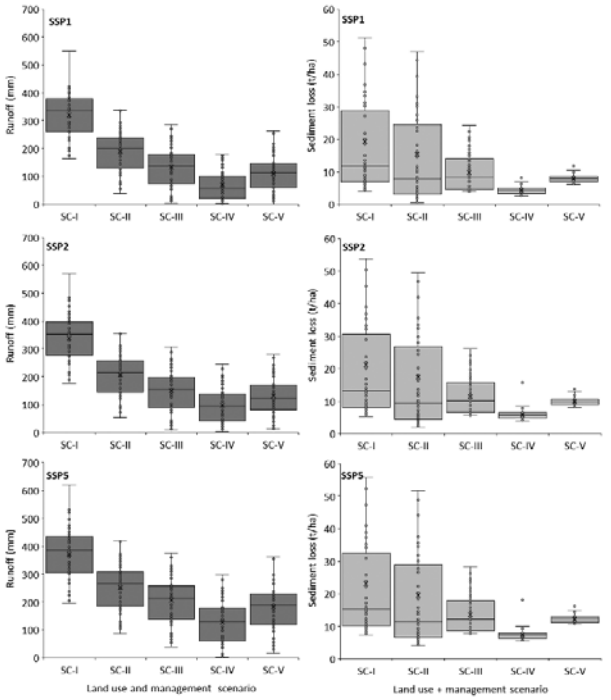


Fig. 3. Box plots of runoff and sediment loss under land use and climate change scenarios for the 2050s decade. The horizontal lines and × symbols within each box represent the median and mean values, respectively; the boxes represent the interquartile range, and the whiskers represent the 95% confidence interval.

Production and plantations in appropriate areas plus best land management practices was the most effective and climate-resilient of the five scenarios. This study suggests that evaluating the impact of land use and management practices under future climate change shows promise for guiding effective and sustainable interventions to adapt to climate change.

Hamed Ebrahimian Taleshi (Visiting Assoc. Prof., Irrigation and Drainage)

April 1, 2022 -March 31, 2023

Determination of leaching depth using a numerical simulation model of salt movement

Soil salinization is one of the major limitations of agricultural production in irrigated farmland in dry regions. Saline soils occur naturally in arid and semiarid regions, and consist up to 48% of farmland in the world (Noborio et al., 1996). As water resources development brings more land into irrigation, the salinity problem is expanding. To control salinity, leaching is widely practiced as the most effective method. To determine the amount of leaching (leaching depth), procedure of FAO irrigation and drainage paper 29 (Ayers and Westcot, 1985) has been commonly used. However, the equation presented in the guideline is based on an unrealistic steady-state one-dimensional solution of solute transport. Relying upon the conventional scheme may have led to over use of precious water and/or reduced yield and net income. We may improve the efficiency of leaching and net income by fully utilizing the fruits of basic studies for predicting the movement of water, heat, and solute in soils.

Therefore, the main aim of our research during April 1st 2022 – March 31th 2023 at ALRC, Tottori University is to present a new scheme to determine leaching depth such that net income is maximized considering price of water using a numerical model, WASH-2D, to solve two-dimensional water, heat and solute movement in root zone and quantitative weather forecast.

This research included two parts: 1) Pot experiments in order to determine crop response function parameters to salinity and drought stresses and 2) field experiments and simulation study in order to optimize irrigation depth under saline water application. The pot and field experiments were conducted for sweet corn (May-August in 2022) and broccoli (Oct 2022- Jan 2023). In addition, the pot experiments were also carried out for sesame and Amaranthus in summer 2022. Three treatments including control (C, i.e., without drought and salinity stress), drought stress (W) and salinity stress (S) were investigated with three replicates for the pot experiment. An inverse approach and a simplified bulk method were employed to determine drought and salinity stress response functions. In addition, each crop was grown under four treatments inside a small greenhouse at ALRC:

C: Leaching is performed when monitored salinity in the root zone reaches at critical level of crop and amount is determined according to FAO's guideline. Irrigation using saline water is automatically performed in order to return volumetric water content to field capacity in the root zone (automated drip irrigation); **F**: As same as the first treatment, but only freshwater is applied for irrigation; **M**: As same as C, but leaching is carried out only once at the middle of the growing season; **O**: Leaching is unintentionally performed via the optimized irrigation scheme using saline water. In this scheme, irrigation depth is determined such that net income is maximized considering the price of water and weather forecasts using the WASH_2D model.

Results indicated that the bulk method gives acceptable results even without using soil moisture sensors (Table 1). Crop parameter values obtained in this study could be used for plant growth simulation, irrigation scheduling, salinity management. There was no significant difference between the salinity treatments in terms of crop yield, but water use was significantly decreased through the optimized irrigation. The control treatment had a significant difference with the salinity treatments in terms of crop yield. Although O gave smaller irrigation depth, its net income is almost the same as C since cost for water is rather low. The O treatment had a significant difference with other treatments in terms of water productivity (Fig. 1). The optimized irrigation could increase water productivity and farmer net income substantially. The WASH_2D simulated soil water content and salt distribution well. The optimized irrigation scheme not only allowed the use of saline water in irrigation without significant crop yield reduction, but also maximized farmer's net income. **A poster of the sweet corn pot experiments was presented at ALRC annual seminar in December 2022. Articles** under preparation and submission for publication:

1. Drought and salinity stress response functions for sweet corn
2. Determination of sesame response function parameters under drought and salinity stresses
3. Optimization of irrigation depth using a numerical simulation model of salt movement

Ongoing work is to numerically investigate various scenarios of leaching management after calibration of the WASH_2D model using the experimental data.

Table 1. Sweet corn parameter values for drought and salinity stresses (h_{50}, h_{o50} and p are the parameters of the Feddes's root water uptake function).

Method	Parameter	Salinity stress	Drought stress
Bulk	h_{o50} (-cm)	5688	-
	h_{50} (-cm)	-	3329
	p	1.18	2.92
Inverse	h_{o50} (-cm)	4734	-
	h_{50} (-cm)	-	3179
	p	0.88	6.96

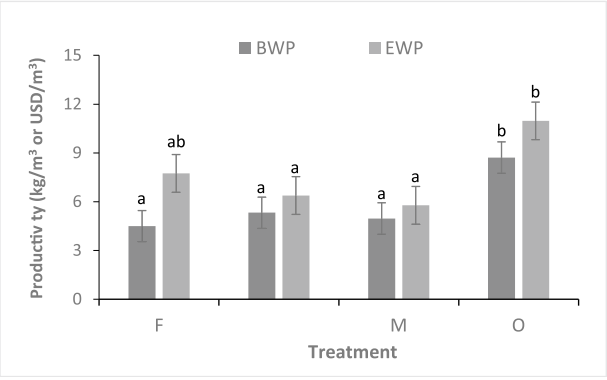


Figure 1. Comparison of Biophysical Water Productivity (BWP) and Economic Water Productivity (EWP) among the treatments for broccoli.

(4) プロジェクト研究員

留森　寿士（乾燥地植物資源バンク室）

乾燥地は、生産性が低いため貧困度が高く、さらに生態系も脆弱なため、過放牧や過伐採、過耕作などの人為的要因により砂漠化が進んでいる。これら乾燥地が抱える問題に対処するため、地域住民の従前の農業形態や生活様式を極力変えない、環境保全と貧困削減を同時に達成する新しい栽培・緑化手法を開発することを目指している。このため、①植物資源の有効活用、②環境耐性を持つ品種・系統の開発、③乾燥地に適した栽培・緑化手法の開発を行っている。

バイオ燃料生産は日常生活に必要なエネルギーの確保のみならず、慢性的な貧困を抱える乾燥地の農村社会における収入の向上による貧困削減の手段として期待され、導入が促進されている。さらに、植物由来の原料を燃焼して排出される二酸化炭素は、植物が大気中から吸収したものであるため、二酸化炭素の排出量はゼロと考えられ、地球温暖化防止の対策として、石油に替わる非枯渇性資源として注目されている。しかし、乾燥地における植物によるバイオ燃料生産は、順調に進んでいるとは言えない。そこで、乾燥地での栽培が期待される油料植物であるジャトロファの植物資源を活用した、生産向上に資する研究を進めている。

本年度は、以下の研究を進めた。

- ジャトロファの耐寒性系統を作るため、系統を選抜した。
- 種間雑種ジャトロファを開発した。
- 土本ら（大阪大学）と共同で、油料植物の乾燥地での生産性向上に関する研究を行った。

(4) Project Researchers

Hisashi Tomemori (Project Researcher, Laboratory of Arid Land Plant Resources)

Owing to the low land productivity, drylands have high poverty rates. Furthermore, because their ecosystems are fragile, desertification is proceeding due to anthropogenic factors including overgrazing, excessive logging, and overcultivation. To deal with the problems faced by drylands, we aim to develop new cultivation and greening techniques that achieve both environmental conservation and poverty reduction with minimal changes to the inhabitants' customary forms of agriculture and ways of life. For this purpose, we are developing: (1) ways to effectively use plant resources; (2) crop varieties and strains with environmental tolerance; and (3) cultivation and greening methods suited to drylands.

Biofuel production is being encouraged because it offers hope not only for securing the energy needed for daily living, but also for providing a means of reducing poverty by raising incomes in dryland rural societies, which suffer from chronic poverty. Furthermore, because the carbon dioxide emitted by the combustion of plant-based materials was absorbed by plants from the atmosphere, CO_2 emissions are deemed to be zero; therefore, biofuels are in the spotlight as a way to arrest global warming and as an inexhaustible resource that will replace oil. And yet, it would be hard to say that biofuel production from plants in drylands is proceeding smoothly. For this reason, we are conducting research that will help improve the production of *Jatropha*, a drought-tolerant oil plant with prospects for dryland cultivation by utilizing of plant resources.

For the fiscal year 2022 we promoted the following research.

- I selected *Jatropha* plants in order to make the cold-tolerant variety.
- I developed interspecific hybrid *Jatropha*.
- In collaboration with Dr. Tsuchimoto and others at Osaka University, we did research on improve productivity of oil plants in arid lands.

Upper left: Seedlings of hybrid *Jatropha*.
Lower left: One of the hybrid *Jatropha* flowers.
Right: Selection of cold-tolerant *Jatropha* in the field.

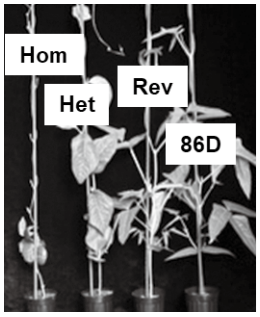
Edet Offiong Ukpong (Project Researcher, Plant Cytogenetics)
Project Name: Hy-Gain for Smallholders (Cowpea)
Project Leader: Takayoshii Ishii
Funding: Bill & Melinda Gates Foundation, USA via University of Queensland, Australia

2022 年度も、2021 年度に報告した次の 2 つの研究サブタイトルについて研究活動を継続しました。

1. 潜在的なセントロメア特異的ヒストン 3 (CENH3) 媒介ササゲゲノム除去 (GEM) 誘導物質の開発とテスト。
2. 2021 年度の圃場栽培中に特定されたササゲ自然変異株の特性評価。

2021 年度の報告書で説明したように、倍数一倍体（DH）育種により一世代でホモ接合系統の作出が可能となり、改良品種の開発に必要な時間が短縮されます。CENH3 を介した GEM 誘導は DH を支援する方法の 1 つです。育種。ササゲにおける CENH3 媒介 GEM 誘導の適用性をさらに調査するために、野生型および CRISPR/Cas9 編集ノックアウトおよびインフレーム欠失対立遺伝子のすべての可能な対立遺伝子の組み合わせを使用して、追加の GEM 誘導因子候補を作成してテストしました。 候補 GEM インデューサーのすべての変異体は、ゲノム編集が行われた元のササゲ遺伝的背景 (IT86D-1010) では一倍性を誘導できなかったため、戻し交配によって、編集した対立遺伝子を別のササゲ遺伝子型である日本のササゲ品種であるササケに移しました。この戦略は大きな期待を示しており、得られた結果の検証が進行中です。

2021 年度に特定され報告されたササゲの単葉自然変異株の特性評価は、2022 年度も継続されました。 突然変異が優性であることを示した遺伝子分析に続いて、突然変異植物と野生型遺伝子型 IT86D-1010 の比較農業形態学的評価とバルク RNA-Seq 分析を実施しました。 RNA-Seq データの詳細な分析により、野生型と変異体の間で差次的に発現される遺伝子、および変異に関連する候補遺伝子が明らかになりました。



- **Hom: homozygous mutant**
- **Het: heterozygous mutant**
- **Rev: wild-type revertant**
- **86D: IT86D-1010 wild-type**

Morphological variations between IT86D-1010 wild-type, wild-type revertant, heterozygous and homozygous mutants

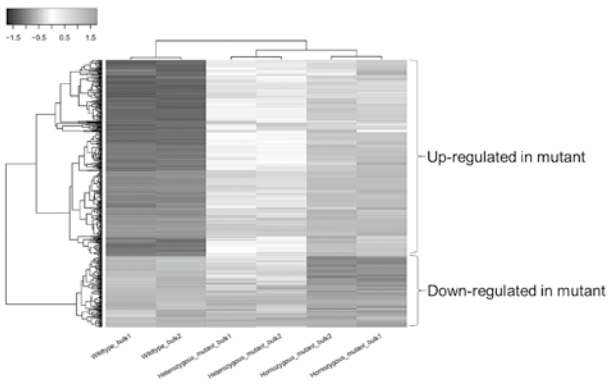
Offiong Ukpong Edet (Project Researcher, Plant Cytogenetics)
Project Name: Hy-Gain for Smallholders (Cowpea)
Project Leader: Takayoshii Ishii
Funding: Bill & Melinda Gates Foundation, USA via University of Queensland, Australia

In FY2022, I continued my research activities in two of the research sub-titles I reported on in FY2021:

1. Development and testing of potential centromere-specific histone 3 (CENH3)-mediated cowpea genome elimination (GEM) inducers.
2. Characterization of a spontaneous cowpea mutant identified during FY2021 field cultivation.

As explained in my FY2021 report, doubled haploid (DH) breeding allows homozygous lines to be produced in a single generation, reducing the time needed for the development of improved plant cultivars, and CENH3-mediated GEM induction is one of the methods that aid DH breeding. To further investigate the applicability of CENH3-mediated GEM induction in cowpea, I produced and tested additional GEM inducer candidates, with all the possible allelic combinations of wild-type and CRISPR/Cas9-edited knockout and in-frame deletion alleles. As all the variants of candidate GEM inducers failed to induce haploidy in the original cowpea genetic background (IT86D-1010) with which genome editing was done, I transferred, through backcrossing, the edited alleles to another cowpea genotype, Sasaque, a Japanese cowpea cultivar. This strategy showed great promise, and validation of the results obtained is ongoing.

Characterization of the spontaneous unifoliate cowpea mutant identified and reported in FY2021 continued in FY2022. Following the genetic analyses which indicated that the mutation is dominant, I conducted comparative agro-morphological evaluation and bulk RNA-Seq analysis of the mutant plants and wild-type genotype, IT86D-1010. Detailed analyses of the RNA-Seq data revealed differentially expressed genes between the wild-type and mutants, and candidate genes associated with the mutation.



Heatmap of differentially expressed genes significantly upregulated or repressed in the mutant segregants

Nasrein Mohamed Kamal (Project researcher, Development of Climate Change Resilient Innovative Technologies for Sustainable Wheat Production in Dry and Heat Prone Agro-ecologies of Sudan and Sub-Saharan Africa, under the program of Science and Technology Research Partnership for Sustainable Development (SATREPS)

(1) Wheat: Protective and defensive roles of wheat *Hl2* gene against drought stress revealed by comparative morpho-physiological and biochemical profiling

Leaf hair can protect plants against drought stress. We studied the variation in tolerance to drought and tested the hypothesis that:1) drought tolerance is associated with leaf hair density; and 2) morphological and physiological traits are affected due to the absence or presence of hairy leaf gene *HL2*, and 3) leaf hair production is increased in response to drought stress in wheat. This study aimed to investigate the morpho-physiological, mineral content, and metabolomic changes under irrigated and drought conditions due to introducing or removing *Hl2* to prove the direct or indirect relationship between leaf hair traits and drought tolerance. Two wheat genotypes (KB, hairy) and (CS, sparse hair) with their near-isogenic lines (NILs), NIL from KB, with *hl2*, and NIL from CS, with *HL2*, were evaluated under irrigated control and drought conditions. Morphological and physiological traits, metabolome profile (LC−MS/MS), minerals content (ICP−MS/MS), and carbon isotope composition (IR−MS) analyses were conducted to test and validate the three hypotheses. We also studied the impact of the *Hl2* gene on the stomata's density and size under control and drought. Preliminary results indicated that introducing *Hl2* improves the drought tolerance of CS (Fig. 1). Moreover, leaf hair is physiologically active under drought stress, mainly through the potential production of enzymes that contribute to phenolic compounds, hormone balance and amino acids with important roles in drought stress tolerance. We propose that the introgression of *Hl2* (leaf hair) is associated with the drought tolerance of wheat.

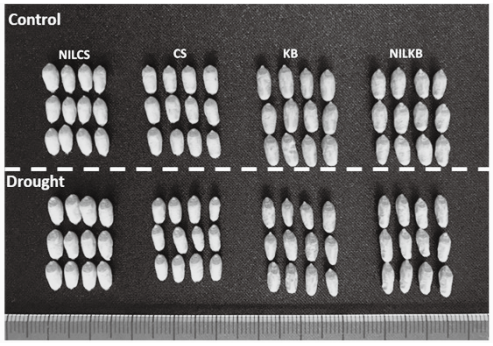


Figure 1. Grain's photograph for CS, NILCS, KB, NILKB under control and drought conditions.

(2) Sorghum: Genetic variation for grain nutritional profile and yield potential in sorghum and the possibility of selection for drought tolerance under irrigated conditions

Sorghum (*Sorghum bicolor*) is an important cereal crop grown in arid and semi-arid regions. Increasing grain nutritional value in sorghum is a paramount breeding objective, as is increasing drought tolerance (DR), because sorghum is grown mainly in drought-prone areas. The genetic basis of grain nutritional traits remains largely unknown.

This study assessed natural variation available in 167 sorghum accessions from around the globe to identify novel genes or genomic regions with potential for improving grain nutritional value, and to study associations between DR traits and grain weight and nutritional composition. We dissected the genetic architecture of grain nutritional composition, protein content, thousand-kernel weight (TKW), and plant height (PH) in sorghum through GWAS of 163 unique African and Asian accessions (Fig.1) under irrigated and post-flowering drought conditions. Several QTLs were detected. Some were significantly associated with DR, TKW, PH, protein, and Zn, Mn, and Ca contents (Fig. 2).

This study provides a valuable resource for selecting landraces for use in sorghum breeding programs and for identifying loci that may contribute to grain nutrition and weight with the hopes of producing cultivars that combine improved yield traits, nutrition, and drought tolerance.

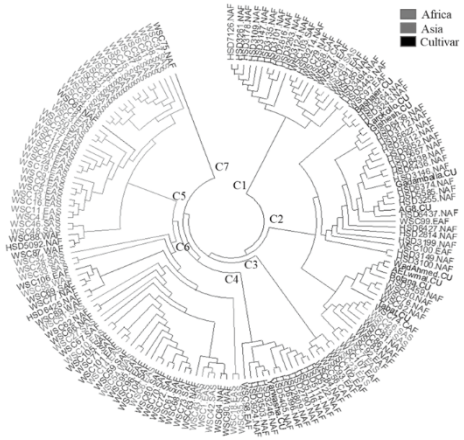


Figure 1. Neighbor-joining phylogenetic tree of the 163 sorghum accessions.

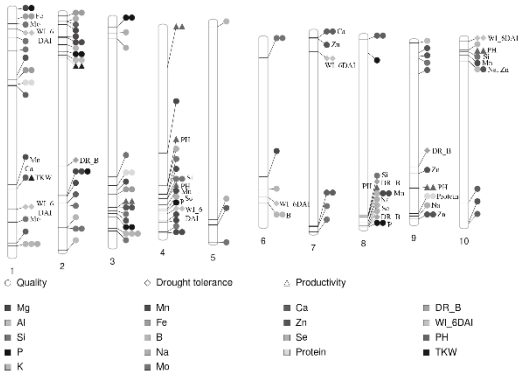


Figure 2. Significant marker-trait associations (MTAs) for quality, drought tolerance and productivity (yield and plant height), related traits in 167 sorghum accessions.

Mohammed Yousif Balla (Project Researcher, SATREPS Project)

Utilizing the genetic diversity of wild wheat relatives is widely accepted as a key strategy to improve wheat grown under changing climates, particularly high temperatures. To this end, two platforms containing introgressions from wild wheat relatives were previously established on elite wheat genetic backgrounds. The first one named multiple synthetic derivative lines (MSD), possesses a large diversity of Aegilops tauschii in a background of cultivated bread wheat (Triticum aestivum). The second one is named multiple derivative lines (MDLs), containing introgressions from nine wild emmer wheat accessions (T. dicoccoides) on background of elite durum wheat cultivar (T. durum). From both MDL/MSD platforms, numerous quantitative trait loci (QTLs) and marker-trait associations (MTAs) linked with heat stress tolerance traits have been identified. However, the direct use of such QTLs/MTAs in breeding programs remains challenging. Therefore, a practical solution is to validate these QTLs/MTAs before their use in a breeding program. Therefore, my research objective is to develop and validate breeder-friendly markers for marker-assisted selection targeting QTLs associated with heat stress tolerance traits in wheat. Accordingly, my research activities during fiscal year 2022 focused on:

(1) Selection of candidate lines from MDL/MSD populations containing favorable alleles from wild relatives.

(2) Develop new molecular markers to amplify target genomic regions and distinguish favorable wild relative alleles in candidate lines from recurrent parent alleles in specific genomic loci.

(3) Developing near-isogenic lines (NILs), by crossing and backcrossing candidate lines (from MDL/MSD populations as donor parents) with elite durum and bread wheat cultivars as recurrent parent. The elite durum and bread wheat cultivars are 'Miki 3' and 'Norin 61', respectively.

Based on the above activities, our preliminary results revealed that the developed molecular markers successfully amplified and discriminate the favorable introgressed wild relative alleles in selected MDL/MSD lines compared with recurrent parent alleles (Figure 1 and Figure 2). Moreover, the introgressed wild relative in the MDL029 and MDL114 lines were absent from elite durum wheat cultivars being bred for heat stress tolerance at such locus (Figure 3).

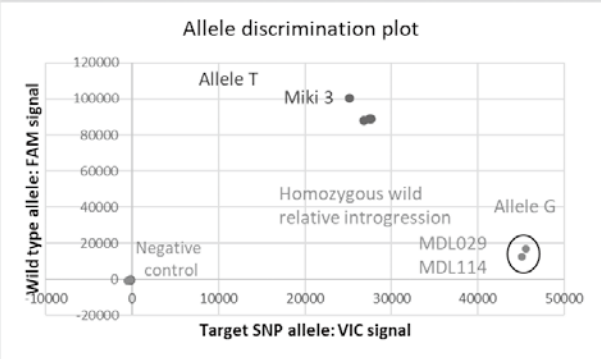


Figure 1. Validation introgressed wild relative allele (G) in the MDL029 and MDL114 compared with recurrent parent allele (T) 'Miki 3' for the target locus containing QTL control biomass on chromosome 3A identified under heat stress condition.

This result will facilitate the development of new recombinant inbred lines with different genetic backgrounds and use such markers to track and validate this QTLs.

According to these findings, we developed NILs by crossing and backcrossing MDL/MSD candidate lines with elite wheat cultivars (Miki3/Norin 61) by taking advantage of the speed breeding technology (Figure 4). Moreover, the target QTLs were tracked using developed molecular markers in each generation round.

For future work, developed NILs will be evaluated under heat stress conditions to estimate the additive value of target QTLs. Validated markers will be used as marker-assisted selection targeting unique wild relative alleles to improve wheat grown under heat stress conditions.

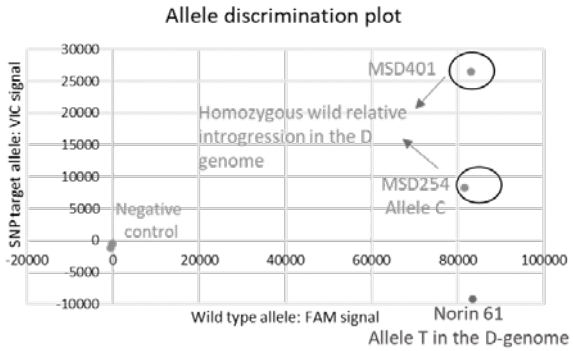


Figure 2. Validation introgressed wild relative allele (C) in the D-genome of the MSD254 and MSD401 compared with Norin 61 allele (T) for the target locus containing QTL control grain yield on chromosome 6D identified under heat stress condition.

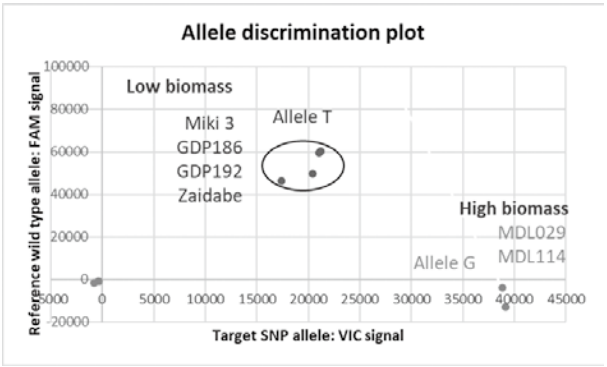


Figure 3. Validation introgressed wild relative allele (G) in the MDL029 and MDL114 compare with elite durum wheat cultivars being bred for heat stress tolerance. The target locus in the MDL lines containing QTL control biomass on chromosome 3A which is identified under heat stress condition.

Figure 4. Speed breeding technology used to develop near-isogenic lines by crossing and backcrossing selected MSD/MDL candidate lines containing favorable wild relatives' alleles with elite durum (Miki 3) and bread (Norin 61) wheat cultivars.

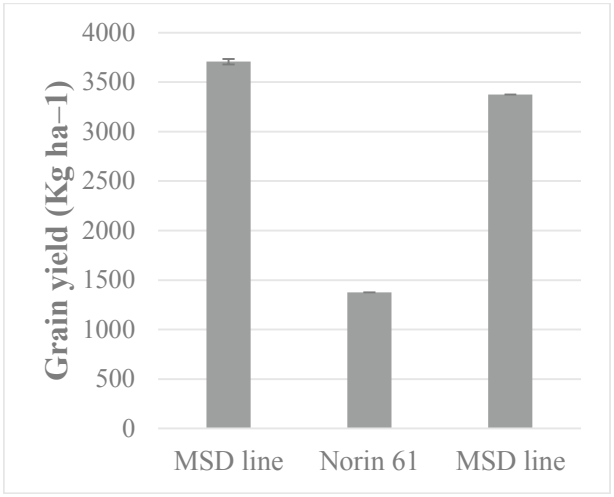
Michael O. Itam (Project Researcher)

Development of wild tetraploid wheat germplasm for breeding heat-tolerant bread wheat by accumulating QTLs

Heat stress is a recurrent issue affecting wheat global productivity. The aim of this study was to develop heat-tolerant bread wheat lines using wild tetraploid wheat as a source of tolerance genes. During the period of April 2022 to July 2022, the following activities related to the project were carried out:

1. Selection of candidate quantitative trait loci (QTLs) controlling heat tolerance as identified in our previous studies.
2. Selection of candidate lines from bread wheat and tetraploid wheat populations containing genes from wild relatives.
3. Crossing of lines to develop near-isogenic lines based on the selected QTLs.
4. Modification of a simple speed breeding technique to facilitate early flowering.
5. Development of Taq-man probes for marker-assisted selection based on allele discrimination.

This study will facilitate the development of heat-tolerant lines and promote the utilization of wheat wild germplasm for wheat improvement especially for heat stress tolerance.



Selected lines showing high yield compared to their backcross parent, Norin 61, are being used for further breeding for heat tolerance.

A simple speed breeding technique to develop near-isogenic lines using alleles from Ae. tauschii, a wheat relative.

中原　浩貴（植物 - 細菌相互作用学）

植物に耐塩性と病害抵抗性を複合的に誘導する細菌菌株の探索と作用機構の解明に関する研究を日本学術振興会特別研究員研究奨励費、課題番号 20J00615 の助成によって実施し、主に以下の成果が得られた。

（1）トマトにおいて耐塩性と病害抵抗性を誘導する細菌菌株を効率的に選抜するために、最適なトマト品種、処理条件および接種方法を検討し、選抜方法を確立した。本選抜法で新たに分離した細菌株の中から病害防除効果と耐塩性（塩処理条件における生育促進効果）の一方または両方をトマトに付与する有用細菌菌株を選抜した（Fig. 1）。

（2）有用菌株の植物への作用機構の解明のため、光合成、ICP-MS を用いた植物の無機成分吸収への影響、リアルタイム PCR と RNA-seq 解析を用いた植物への関連遺伝子の発現誘導、細菌の抗菌物質および植物生育促進因子の生産について調査した。有用細菌による病害防除機構の要因として、有用細菌による植物への抵抗性誘導（PR タンパク質遺伝子や病害防御関連酵素遺伝子の発現誘導）と有用細菌の病原菌に対する抗菌作用が関与することがわかった。有用細菌による植物の耐塩性向上機構の要因として、有用細菌は塩処理条件でも植物内で高密度に定着すること、有用細菌による植物の光合成活性の向上、無機成分吸収の恒常性の維持、抗酸化関連酵素遺伝子の発現誘導、有用細菌の植物成長促進因子の生産等が関与することがわかった。

また、共同研究として、熊本県立大学（代表）、滋賀大学、鳥取大学（フィールドサイエンスセンターおよび乾燥地研究センター）との共同研究（日本学術振興会基盤研究 B、課題番号 19H03091 の助成により実施）に参画し、植物病原細菌青枯病菌の表現型変異を利用した新しい環境保全型の病害防除技術の開発に関する研究を実施した。

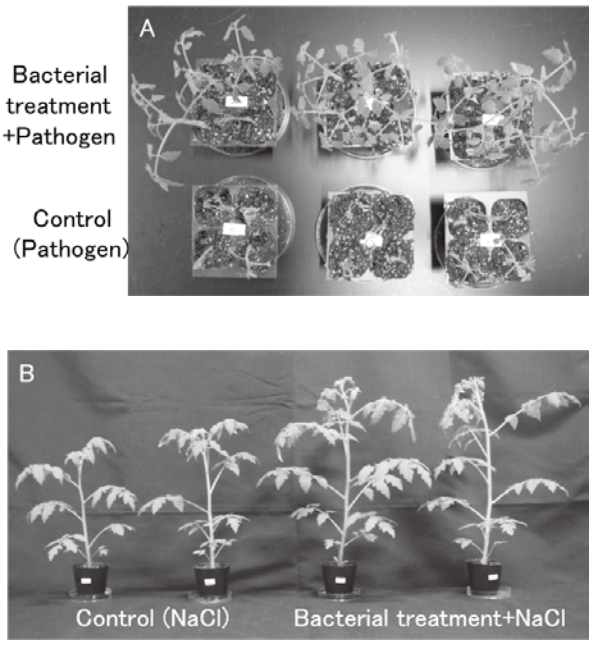


Fig. 1　Induction of disease resistance against bacterial wilt disease (A) and salinity tolerance (B) in tomato plants by the inoculation of same bacterial strain of *Pseudomonas* sp.

Hiroki Nakahara (JSPS Research Fellow PD, Plant-Bacterial Interactions)

Research on the screening for bacterial strains that induce combined salinity tolerance and disease resistance in plants and elucidation of their mechanisms of action were conducted with the support of JSPS Postdoctoral Fellowship, Project No. 20J00615, and the following results were mainly obtained.

(1) To efficiently select bacterial strains that induce salinity tolerance and disease resistance in tomato, I investigated the optimal tomato cultivar, treatment conditions, and inoculation methods, and established a selection method of effective bacterial strains. Among the bacterial strains newly isolated, I selected useful bacterial strains that induced either or both disease control effect and salinity tolerance (plant growth promotion effect under salinity conditions) on tomatoes by using this selection method (Fig. 1).

(2) To elucidate the action of the plants inoculated with the selected strains, I investigate their effects on photosynthesis, plant absorption of inorganic components using ICP-MS, induction of expression of related genes in plants using Real-Time PCR and RNA-seq analysis, and production of antibacterial substances and plant growth-promoting factors by bacterial strains. It was found that the mechanism of disease control by beneficial bacteria involves the induction of resistance (PR protein genes and disease defense-related enzyme genes) in plants by beneficial bacteria and the antibacterial action of beneficial bacteria against pathogenic bacteria. It was found that the mechanism of the improvement of salinity tolerance in plants by beneficial bacteria involves the beneficial bacteria colonize plants at high density even under salinity treatment conditions, improvement of the photosynthetic activity of plants, maintain the homeostasis of inorganic component absorption, induction of expression of antioxidation-related enzyme genes, and production of plant growth promoting factors by beneficial bacteria.

I also participated in a joint research project (supported by JSPS Grant-in-Aid for Scientific Research B, Project No. 19H03091) with Prefectural University of Kumamoto (representative), Shiga University, and Tottori University (Field Science Center and Arid Land Research Center). We conducted research on the development of new environmentally friendly disease control technology using phenotypic conversion of the plant pathogenic bacterium *Ralstonia solanacearum*.

1.2　研究プロジェクト・教育プログラム

(1) SATREPS　エチオピアプロジェクト

乾燥地研究センターの恒川篤史教授を研究代表者とする研究課題が、科学技術振興機構（JST）の国際科学技術共同研究推進事業「地球規模課題対応国際科学技術協力プログラム（SATREPS）」における平成 28 年度新規研究課題に採択された。

鳥取大学と相手国研究機関であるバハルダール大学は、アムハラ州農業研究センター、アンダサ研究センター等、現地研究機関の協力も得て、平成 29 年度から国際共同研究を開始し、令和 4 年度に終了した。

研究課題名：
砂漠化対処に向けた次世代型「持続可能な土地管理（SLM）」フレームワークの開発

相手国研究機関：
バハルダール大学

研究期間：
6 年間（平成 29 年度～令和 4 年度）

相手国：
エチオピア連邦民主共和国

研究課題の概要：

本研究は、エチオピアを対象にして、土壌侵食防止機能の強化、土地生産力の向上、住民の所得向上を組み込んだ次世代型持続可能な土地管理（SLM: Sustainable Land Management）のフレームワークを開発することを目的とする。「持続可能な土地管理」は、砂漠化対処に向けて世界で広く実施されているが、その効果や持続性の問題が指摘されている。具体的には、降雨による土壌侵食の激しい青ナイル川上流域の 3 地域（高地、中間地、低地）に設置する研究サイトにおいて、土壌侵食の削減や耕畜連携システムの導入により土地生産力を向上する技術を開発し、さらにそれを住民の生計向上につなげる手法を開発する。最終的には、開発された個別要素技術と普及していくための取り組み・手法を定式化し、次世代型 SLM フレームワーク（エチオピアモデル）を提案する。事業終了後は、青ナイル川流域及び世界の乾燥地への展開を目指している。

本プロジェクトでは、13 件の最良 SLM 技術と 4 件のアプローチからなる次世代型 SLM フレームワークを作成した（Output 4）。現地のステークホルダーの意見を取り入れながら SLM ガイドラインとポリシーブリーフを作成し、実装に向けて中央・地方政府、国際開発パートナー、地域ステークホルダーに提案した。具体的には、統合型小流域管理技術・アプローチにより、本プロジェクトでは土壌侵食量の 66 ～ 96% 削減（Output 1）、土地生産力の 49 ～ 134% 向上（Output 2）および貧困農家所得の約 35% 向上（Output 3）を可能にする土地管理シナリオを作成した。

1.2 Research Projects and Training Programs

(1) SATREPS – Ethiopia Project

A research project proposed by ALRC's Professor Atsushi Tsunekawa as its principal investigator was selected as one of the Fiscal Year 2016 Science and Technology Research Partnership for Sustainable Development (SATREPS) programs by Japan Science and Technology Agency (JST).

Based on the needs of developing countries, JST and JICA cooperate to promote international joint research targeting global issues with an objective of future utilization of research outcomes. Implemented through collaboration with ODA, the aim of the program is to acquire new knowledge and technology that lead to the resolution of global issues and the advance of science and technology, and through this process, to create innovations.

Tottori University and its Ethiopian counterpart Bahir Dar University, in collaboration with Amhara Regional Agricultural Research Institute (ARARI), Andassa Research Center and other research institutes in Ethiopia, have started full-scale operation of the project since FY 2017.

Project Title
Development of Next-Generation Sustainable Land Management (SLM) Framework to Combat Desertification

Partner Country
Federal Democratic Republic of Ethiopia

Research Period
FY 2017 - FY 2022 (six years)

Project Summary

This project aims to develop a next-generation Sustainable Land Management (SLM) framework that can contribute for a significant reduction of soil erosion, improvement of land productivity and livelihood in Ethiopia. Sustainable Land Management has been widely implemented throughout the world as a response to desertification/land degradation, but there are issues about its effectiveness and sustainability. Specifically, in the research sites to be established in three contrasting environments (highland, midland, and lowland) of the Upper Blue Nile River basin of Ethiopia, there is extremely high soil erosion risk that affects downstream countries as well. This project will (1) develop effective technologies for soil erosion reduction, (2) develop technologies that can integrate the mixed crop-livestock farming system to improve land productivity of three main land use systems, and (3) link this improved technologies to improvement of the people's livelihoods. Finally, it will formulate the SLM technologies and approaches that have been developed,and propose a next-generation SLM framework (Ethiopian model). After the completion of this project, we aim to expand it to the Blue Nile River Basin areas and other drylands of the world.

The project created a next-generation SLM framework consisting of 13 best SLM technologies and 4 approaches (Output 4). SLM guidelines and policy briefs were developed with input from local stakeholders and proposed to central and local governments, international development partners, and local stakeholders for implementation. Specifically, through integrated small watershed management techniques and approaches, the project developed land management scenarios that could reduce soil erosion by 66-96% (Output 1), increase land productivity by 49-134% (Output 2), and increase poor farmers' income by about 35% (Output 3).

（2）SATREPS　スーダンプロジェクト

乾燥地研究センターの辻本壽教授を研究代表者とする研究課題が、科学技術振興機構（JST）の国際科学技術共同研究推進事業「地球規模課題対応国際科学技術協力プログラム（SATREPS）」における平成 30 年度新規研究課題に採択された。

鳥取大学と相手国研究機関であるスーダン農業研究機構およびスーダン気象庁は、スーダン農林省、国際協力省、製粉会社等、スーダン国内の産官の協力を得て、令和元年度から国際共同研究を開始した。

研究課題名：
スーダンおよびサブサハラアフリカの乾燥・高温農業生態系において持続的にコムギを生産するための革新的な気候変動耐性技術の開発

相手国研究機関：
スーダン農業研究機構、スーダン気象庁

研究期間：
5 年間（令和元年度～令和 5 年度）

相手国：
スーダン共和国

研究課題の概要：

スーダンを含むサブサハラアフリカ地域では、今後、世界で最も栄養不足人口が増えると予想される。この地域は、コムギに対する需要が特に高いが、乾燥・高温環境がコムギ生産の障害となり、不足分を輸入に頼っているのが現状である。本研究は、乾燥･高温耐性で、高栄養･高品質なコムギ品種を分子育種技術で迅速に開発し、情報通信技術で効果的に普及させることを目的とする。そこで、これまでの研究で開発した乾燥・高温耐性コムギ系統を実験材料とし、サブサハラの環境に適したコムギ品種を作る。また、不良環境下でも栄養や品質の劣化しない遺伝資源を探索する。これらの系統を利用して実用品種を開発するための選抜マーカーを開発する。さらに、耐性の遺伝様式と分子基盤を解明し、気候変動予測に対する成長モデルを作成することで、将来も継続的に品種開発ができる基盤を作る。迅速な品種開発と円滑な新品種普及のために、分子育種施設とイノベーションプラットフォームを設置し、それらを自立的に担う人材を養成する。気候変動に適応するコムギ遺伝資源を開発・利用することにより、この地域の食糧安全保障への貢献を目指す。

令和 4 年度は、COVID-19 の世界的蔓延が沈静化し、専門家をスーダンに派遣し、4 つの州（ゲジラ州、ナイル川州、北部州、カッサラ州）においてイノベーションプラットフォームを実施し、デモンストレーションフィールド等の事業を実施した。また、4 名の長期研修生に博士号を授与することが出来た。さらに、分子育種施設の建設が開始された。多くの機器類が投入され、また業務調整員を駐在して、事業が本格的に再開できた。

(2) SATREPS – Sudan Project

A research project proposed by ALRC's professor Hisashi Tsujimoto as its principal investigator was selected as one of the Fiscal Year 2018 Science and Technology Research Partnership for Sustainable Development (SATREPS) programs by Japan Science and Technology Agency (JST).

Tottori University and its Sudanese counterpart institutions, Agricultural Research Corporation and Sudan Metrological Authority, in cooperation with Sudanese Ministry of Agriculture and Forestry, Ministry of International Cooperation, and other local industries, have started full-scale operation of the project since FY 2019, suported by JST and JICA.

Project Title
Development of Climate Change Resilient Innovaive Technologies for Sustainable Wheat Production in the Dry and Heat Prone Agro-Ecologies of Sudan and Sub-Saharan Africa

Research Institutions in Sudan
Agricultural Research Corporation, Sudan/ Sudan Meteorological Authority

Research Period
FY 2019 - FY 2023 (five years)

Partner Country
The Republic of the Sudan

Project Summary

The sub-Saharan Africa region, including Sudan, has the highest number of undernourished people in the world. In this region, the demand for wheat is particularly high, but the drought and heat are serious obstacles for wheat production. Currently, the region relies on imports and food aids to meet the increasing demand. The purpose of this research is to 1) develop drought and heat tolerant wheat varieties with enhanced nutritional value and bread making quality using speed and molecular breeding techniques and 2) disseminate these varieties efficiently using information communication technology. This project team previously created germplasms tolerant to drought and heat. These germplasms must be useful to develop new tolerant varieties in the region. Also, the team found germplasms that maintain a good nutritional value or bread making quality, even in a poor environment. The team will analyze the genetic base of the tolerance and develop selection markers to proceed with marker-assisted selection to breed new varieties efficiently. Furthermore, by elucidating the genetic and molecular bases of the tolerance and by creating a growth model using the climate change prediction, this project will set a base for future breeding strategies. For speed breeding and smooth dissemination of the new varieties, this project will establish a molecular breeding facility and innovation platform. This project will also develop the capacity of the people who can manage these new facilities. Using the wheat genetic resources that adapt to climate change, this project aims to contribute for food security in the region.

In FY2022, as the global spread of COVID-19 subsided, we sent experts to Sudan, implemented an innovation platforms in four states (Gezira, River Nile, Northern, and Kassala), and conducted demonstration field and other activities. In addition, four long-term trainees were awarded Ph.D. degrees from Graduate School of Tottori University In addition, the construction of a Molecular Breeding Facility was initiated. Much equipment was installed and a project coordinator was stationed at the ARC, allowing the project to resume in earnest.

(3) アフリカ - 日本共同研究プロジェクト

乾燥地研究センターの坪充教授を研究代表者とする研究課題が、科学技術振興機構（JST）の戦略的国際共同研究プログラム（SICORP）「アフリカ - 日本共同研究（AJ-CORE）」における令和 2 年度新規研究課題に採択された。

鳥取大学と相手国研究機関である南アフリカ・農業研究機構およびセネガル農業研究所は、南アフリカ・リンポポ大学およびセネガル・食品技術研究所の協力を得て、令和 3 年度から国際共同研究を開始した。

研究課題名：
アフリカの多様な環境における農業気候リスク管理のためのレジリエント e ファーミングの開発

相手国研究機関：
南アフリカ・農業研究機構、セネガル農業研究所

研究期間：
3 年間（令和 3 年度～令和 5 年度）

相手国：
南アフリカ共和国、セネガル共和国

研究課題の概要：

本研究は、天気予報、季節予報および将来気候変動予測を利用した干ばつ緩和方策を立てる意思決定支援システムの開発による、サブサハラアフリカの農業干ばつリスク管理における科学技術の発展を目的とする。したがって、現在気候と将来気候の季節性に対する作物応答を理解するために、学際的な研究を行っている。具体的には、国際共同研究を通して、農家の脆弱性評価および気候変動の影響評価に基づく気候リスク管理のための意思決定支援システムの開発を目指し、中期予報・長期予報の精度向上、気候変動対応型農業技術を取り入れた作物モデリング手法の向上、および気候変動下での農業干ばつ緩和戦略の策定に取り組んでいる。南アフリカとセネガルのアフリカ側研究チームは、気候解析、農家調査および圃場実験を行い、モデルシミュレーションについては、日本側研究チームが中心的役割を担っている。本研究は、サブサハラアフリカで増加傾向にある極端気象現象による農業干ばつへの対処策を講じるものであり、南アフリカとセネガルの農業開発計画に貢献する一方、干ばつに脆弱な小規模農業における食料問題の解決に資する。

令和 4 年度は、作物モデルの精度検証および農家意思決定プロセスのフレームワーク構築に加えて、気候変動対応型農業技術を取り入れたモデルの開発を目標とし、次の 3 つの研究活動に取り組んだ。①作物モデルで計算される収量推定値を実測値と比較し、モデル検証を行った。②イネ科作物とマメ科作物の間作および圃場内集水に関するモデリング手法を特定した。③播種前と播種後の農家意思決定プロセスのシナリオを作成した。

(3) AJ-CORE Project

A research project proposed by ALRC's professor Mitsuru Tsubo as its principal investigator was selected as one of the Strategic International Collaborative Research Program (SICORP) - Africa-Japan Collaborative Research (AJ-CORE) projects by Japan Science and Technology Agency (JST) in FY 2020.

Tottori University and its counterpart institutions, Agricultural Research Council, South Africa and Senegalese Institute for Agricultural Research, in cooperation with University of Limpopo, South Africa and Institute of Food Technology, Senegal, started international collaboration in FY 2021.

Project Title
Development of Resilient E-farming for agro-climate risk management in African Multi-environments (DREAM)

Research Institutions
Agricultural Research Council, South Africa
Senegalese Institute for Agricultural Research

Research Period
FY 2021 - FY 2023 (three years)

Partner Country
Republic of South Africa, Republic of Senegal

Project Summary

This research aims to advance science and technology in agricultural drought risk management in sub-Saharan Africa by developing a decision support system to formulate drought mitigation strategies using weather forecasts, seasonal forecasts, and projections of future climate change. Therefore, interdisciplinary research has been conducted to understand crop responses to the seasonality of current and future climates. Specifically, through international collaboration, this research has improved the accuracy of medium- and long-term forecasts and crop modeling methods incorporating climate-smart agricultural technologies and has developed agricultural drought mitigation strategies under climate change, aiming to develop a decision support system for climate risk management based on farmers' vulnerability assessment and climate change impact assessment. The South African and Senegalese research teams have conducted climate analysis, farmer surveys, and field experiments, while the Japanese research team has played a central role in model simulations. This research will take measures to cope with agricultural droughts caused by extreme weather events, which are on the increase in sub-Saharan Africa, contributing to solving food problems in small-scale agriculture vulnerable to drought, while contributing to agricultural development plans in South Africa and Senegal.

In FY2022, we conducted the following three research activities with the objectives of developing a model that incorporates climate-smart agricultural technologies in addition to validating the accuracy of the crop model and developing a framework for the process of farmers' decision-making. We (1) validated the crop model by comparing the calculated yields with the actual measurements, (2) identified modeling approaches for cereal-legume intercropping and in-field water harvesting, and (3) developed scenarios of farmers' decision-making before and after sowing.

1.3 共同研究 / Joint Research

(1) 戦略的重点研究 / Strategic Focused Research

戦略的重点研究 1 Strategic Focused Research 1	対応教員 Corresponding Staff	山中　典和 Yamanaka, Norikazu
研究代表者 Principal Researcher	舘野　隆之輔（京都大学フィールド科学教育研究センター） Tateno, Ryunosuke (Field Science Education and Research Center, Kyoto University)	
研究課題 Research Subject	半乾燥地における主要緑化樹種の根圏における微生物多様性と樹木の生理特性 Microbial diversity in the rhizosphere and physiological characteristics of major revegetation trees in a semi-arid region	
共同研究要旨 Summary of Joint Research	Revegetation in a semi-arid region sometimes has been carried out using single tree species including exotic species that have been successful in different regions. However, current revegetation techniques using exotic species are considered problematic from the perspective of the sustainability of semi-arid ecosystems. So it is important to develop revegetation methods that can reliably lead to natural vegetation with multiple ecosystem functions. However, little is known about the relationships among microbial species in the rhizosphere of native tree species that are candidates for planting in this region, and there is also little knowledge of the effects of microbial interrelationships on the physiology and growth of planted trees. Therefore, this study aims to clarify the interrelationships among microbial species in the rhizosphere and their effects on tree physiology and growth in native tree species growing in a native semi-arid forest near the dry limit in the Loess Plateau, China. In FY2022, we were unable to travel to China to conduct field research due to COVID-19. In FY2022, we prepared for the field survey and analyzed the relationship between forest structure, production, nitrogen cycling, plant nitrogen and water use patterns, and soil microbial community structure and diversity using past soil samples collected in the study sites These findings are reported at the Joint Research Meeting. The results were presented at the Joint Research Symposium. In addition, we summarized the results of past research on soil microorganisms conducted at the study site and submitted a paper to an international journal. We also invited one of the collaborators, Prof. Weiyu Shi, to Kyoto as a JSPS Bridge Fellow from January 9 to February 7 to discuss future collaborative research..	

戦略的重点研究 2 Strategic Focused Research 2	対応教員 Corresponding Staff	辻本　壽 Tsujimoto, Hisashi
研究代表者 Principal Researcher	松岡　由浩（神戸大学大学院農学研究科） Matsuoka, Yoshihiro (Graduate School of Agricultural Science, Kobe University)	
研究課題 Research Subject	コムギの乾燥地適応：TU-eFARM と野生遺伝資源を活用した節水性形質の研究 Dryland adaptation in wheat: an empirical study on water-use efficiency traits using TU-eFARM and wild genetic resources	
共同研究要旨 Summary of Joint Research	Today, when threats such as climate change are increasing, it is urgent to develop crop varieties with stable productivity in arid lands. As for bread wheat, which is the world's main crop, pre-breeding was conducted at the Arid Land Research Center of Tottori University, based on the synthetic wheat lines produced by the applicant using *Aegilops tauschii* Coss. (wild relative), and Multiple Synthetic Derivatives (MSD) lines were produced. In addition, TU-eFARM, which can control precipitation with rainout shelters, was installed at the Arid Land Research Center of Tottori University, creating an environment for further promoting research on the mechanism of wheat's adaptation to dry land. Based on this situation, we will proceed with research on "how to efficiently breed bread wheat cultivars adapted to arid regions using MSD lines." Specifically, we will focus on a property of photosynthesis, i.e., water use efficiently (WUE) under dry conditions, and by genetically analyzing the mechanism of WUE, we aim to obtain new knowledge on the adaptation mechanism of wheat to dry land. Based on the knowledge and breeding materials obtained, we further aim to develop bread wheat cultivars that are adaptable to arid regions and exhibit high productivity. This year, in the rainout shelter, we started growing recombinant inbred lines (RILs) (221 lines) derived from lines with different WUE that were selected from MSD lines. In addition, we extracted DNA from RILs and acquired genome resequencing data by the Gras-Di method. Furthermore, using the dried leaves that had already Arid Land Research Center, and δ13C data was obtained (high δ13C values are indicative of high WUE). Quantitative Trait Locus (QTL) analysis will be performed using these data to obtain new knowledge about the genetic mechanism of WUE.	

⑵ 一般研究 /General Research

一般研究 1 General Research 1	対応教員 Corresponding Staff	坪　充 Tsubo, Mitsuru
研究代表者 Principal Researcher	藤田　泰成（国際農林水産業研究センター生物資源・利用領域） Fujita, Yasunari (Biological Resources and Post-harvest Division, Japan International Research Center for Agricultural Sciences)	
研究課題 Research Subject	環境シミュレーターを利用したキヌアの過酷環境耐性機構の解明 Elucidation of the mechanism of tolerance to harsh environments in quinoa using an environmental simulator	
共同研究要旨 Summary of Joint Research	This year, a cultivation experiment was conducted to determine the conditions for growing quinoa. In particular, the conditions for growing highland quinoa (northern highland and southern highland quinoa), which is difficult to grow to fruiting in a normal incubator or in Japanese fields, were examined. Cultivation trials were conducted in the subtropical desert simulator at the Arid Land Research Center, Tottori University, from August 23, 2022, using eight quinoa inbred lines bred at JIRCAS and 32 1/5000a Wagener pots. The results of this cultivation trial indicate that the environmental settings used in this study are suitable for growing highland quinoa. Next, using these environmental conditions, a second experiment was conducted from January 10, 2023. In the second cultivation trial, the experiment was conducted with a total of eight trays, one on each of eight rotatable carts. Each tray has 6 pots, for a total of 48 pots in the experiment. The second experiment is a comparative growth study of lowland, southern highland, and northern highland quinoa lines and a study on early maturing traits using early maturing lines. From the second experiment, a web camera was installed and a system was constructed to allow remote observation via a wifi router and repeater.	

一般研究 2 General Research 2	対応教員 Corresponding Staff	辻本　壽 Tsujimoto, Hisashi
研究代表者 Principal Researcher	岡本　昌憲（宇都宮大学バイオサイエンス教育研究センター） Okamoto, Masanori (Center for Bioscience Research and Education, Utsunomiya University)	
研究課題 Research Subject	多重合成コムギ集団から単離したアブシシン酸高感受性系統の分子遺伝学的解析 Molecular genetic analysis for abscisic acid hypersensitive line isolated from multiple synthetic wheat population	
共同研究要旨 Summary of Joint Research	Genetic diversity of wheat is poor compared to other major crops, and it is a major barrier to modern wheat breeding. To overcome this problem, Prof. Tsujimoto generated wheat multiple synthetic derivatives (MSD) populations, which have variation of D genome from many accessions of *Aegilops tauschii*. We have conducted sensitivity tests to the plant hormone abscisic acid (ABA) in the MSD population and have succeeded in isolation of ABA-hypersensitive lines, which may possess water-saving and drought-tolerant traits. We have identified major QTLs associated with ABA sensitivity by NGS technology with F3 population of Norin61 and major ABA-hypersensitive line named as Oka28. As the result, many QTLs were derived from either the A or B genome. Therefore, Langdon and primary synthetic wheat may have high sensitivity to ABA, but the ABA sensitivity of these lines were comparable to that of Norin61. These results revealed that the Oka28 strain acquired high sensitivity to ABA by random introgression of Langdon's A and/or B genome fragments. Using ABA sensitivity as an index, Oka28 line was crossed with Norin61 to generate BC1F4 lines that overcome the tall height of Oka28 line. These lines maintained high sensitivity to ABA and showed higher seed production than Norin61 in the field at Utsunomiya Univ.in FY2022. In addition, these lines also showed high expression of the ABA-responsive gene *TaLEA* before ABA treatment and was significantly increased by ABA treatment than Norin61.	

一般研究 3 General Research 3		対応教員 Corresponding Staff	石井　孝佳 Ishii, Takayoshi
研究代表者 Principal Researcher	最相　大輔（岡山大学資源植物科学研究所） Saisho, Daisuke (Institute of Plant Science and Resources, Okayama University)		
研究課題 Research Subject	乾燥地に最適化したムギ品種の育成に向けて：オオムギおよびパンコムギの節水形質に関わる遺伝構造の解析 Toward the breeding *Triticeae* varieties optimized for drylands: Analysis of Genetic Structures Related to water use efficiency in barley and bread wheat		
共同研究要旨 Summary of Joint Research	This research aims to identify the genetic regions involved in the control of 'water-saving' traits by using the barley chromosome substitution lines (CSSLs) and 'water-saving' bread wheat populations that have been found to have a wide range of variation in our previous studies. The study will use the "EA/IR-MS" at the Arid Land Research Center to deepen our understanding of the identification of genetic regions involved in 'water-saving' traits control and their physiological response mechanisms from the perspective of stomatal closure activity and water use efficiency. This year, we cultivated a barley CSSL population (n=53) that showed a wide range of 'wa-ter-saving' traits by δ13C in our previous studies at the experimental field of the Institute of Plant Science and Resources, Okayama University and prepared the sample for EA/IR-MS analysis. Six replications were set up for each line, and flag leaf samples were obtained from plants grown in multiple fields with different management. In addition, we also conducted sample preparation for EA/IR-MS analysis using the 'water-saving' bread wheat populations at the experimental field of the Arid Land Research Center, Tottori University. As a result of EA/IR-MS analysis of the barley CSSLs, a statistically significant correlation ($r = 0.395$, $p = 0.0029$; $\rho = 0.348$, $p = 0.0092$) was detected between this study and previous studies, suggesting that stable 'water-saving' traits are expressed regardless of differences in cultivation years. The results of the analysis of variance revealed that line differences explained about one-third of all variations ($p < 0.0001$), confirming that there is genetic diversity in barley CSSL populations. EA/IR-MS analysis is currently being conducted for water-saving bread-wheat populations. We plan to continue our research next year by continuing to conduct sample preparations and EA/IR-MS analyses from different environments/seasons to identify genetic regions involved in 'water-saving' traits control in barley and wheat.		

一般研究 4 General Research 4		対応教員 Corresponding Staff	石井　孝佳 Ishii, Takayoshi
研究代表者 Principal Researcher	湯淺　高志（宮崎大学農学部） Yuasa, Takashi (Faculty of Agriculture, University of Miyazaki)		
研究課題 Research Subject	ササゲの乾燥応答長距離シグナルに着目した乾燥耐性品種選抜方法の開発 Development of genetic breeding technique for drought tolerant crops on aspect of drought stress long distance signaling in cowpea		
共同研究要旨 Summary of Joint Research	Cowpea [*Vigna unguiculata* (L.) Walp.] is highly adapted to drought conditions and avoids water loss from leaf by closing stomata via abscisic acid (ABA) signaling. Re-cently, molecular genetic studies in Arabidopsis have revealed that the ABA responses are mediated by CLE peptids and ABA-responsive repressor (ABR1). However, it re-mains unknown whether the CLE peptides and ABR1 are involved in osmotic tolerance of cowpea. Furthermore, to address CLE-mediated root regulation, homedomain type transcription factor involved in meristem regulation was examined by using root of cowpea seedling. At least, two ABR1 ortholog gene and one homeodomain type tran-scription factor, Wuschel ortholog gene, are predicted in cowpea genome by tblastx ho-mology search. Semi-quantitative RT-PCR analysis indicated that drought and salt stresses induced up-regulation of *VuABR1-03g* and *VuABR1-09g*. We examined effects of CLE peptide on expression of *VuWUS* in root cowpea seedlings. CLE peptide down-regulated expression of *VuWUS* but not WUS-related gene, *VuWOX4*. To examine involvement of LRR-RPK in CLE signaling, effects of LRR-RPK2 inhibitor, CZC-54252(CZC) on suppression of root elongation in the presence of CLE25 peptides. Treatment of CZC reagent significantly alleviated suppression of root elongation in the presence of CLE25 peptide. Those data indicated that binding of CLE25 peptide onto LRR-RPK exerts intracellular signaling to repress *VuWUS*, leading to root meristem regulation.		

一般研究 5 General Research 5		対応教員 Corresponding Staff	黒崎　泰典 Kurosaki, Yasunori
研究代表者 Principal Researcher	牧　輝弥（近畿大学理工学部） Maki, Teruya (Faculty of Science and Engineering, Kindai University)		
研究課題 Research Subject	東アジアを越境するバイオエアロゾル：日本本土への拡散・沈着とその生体影響の評価 Dispersion and deposition of Asian-dust bioaerosols in Japanese islands after long-range transportation over East Asia		
共同研究要旨 Summary of Joint Research	Asian dust events are emerging as a significant vehicle for long-range transport of mi-croorganisms. Nonetheless, many factors relating to this highly influential dispersal mechanisms remain vailed in-cluding the variation in dispersal bacterial communities during stochastic desert anthropogenic dust events, and the effect of Asian dust trans-portation on environments and human health around the East Asia. Here, airborne mi-crobial compositions were investigated in the high-altitude aerosols, which were captured at 500 m - 2,500 m altitude on the Osaka Plane and the Noto Peninsula. This was further compared to the ground-level aerosols collected at six sampling sites distributed from Asian dust source region to downwind areas in East Asia (Asian desert; Tsogt-Ovoo, Asian continental cities; Er-enhot, Beijing, Yongin, Japanese island cities; Osaka, Tottori, Kagawa, Suzu). The cell concentrations and taxonomic diversities of airborne bacteria decreased from the Asian continental area to the Japan island area. Terrestrial bacterial populations belonging to Firmicutes and Actinobacteria showed higher relative abundance at high-elevation and Japanese island cities. Mold-type fungi belonging to the class Dothideomycetes suddenly increased the relative abundance during the Asian dust events. The class Dothideomycetes contains Aspergillus species, which has been isolated from the Asian dust aerosols and demonstrated the produce of Aflatoxin with carcinogenic. Additionally, Mycobacterium species occurring the nontuberculous mycobacterial pulmonary disease (NTM-PD) have increased in the high-altitude aerosols in correspondence to the increase of black carbon concentrations. The relative abundance of Mycobacterium sequences were higher in the aerosol samples of Asian continental cities and Japanese cities than in the desert area (Tsogt-Ovoo). Presumably, anthropogenic pollution over East Asia carries potential pathogenic species, which induce NTM-PD and cancer, thereby impacting upon the public health.		

一般研究 6 General Research 6		対応教員 Corresponding Staff	辻本　壽 Tsujimoto, Hisashi
研究代表者 Principal Researcher	平田　翔（九州大学大学院農学研究院） Hirata, Sho (Graduate school of bioresource and bioenvironmental sciences, Kyushu University)		
研究課題 Research Subject	環境ストレス条件下におけるネギ類バイオリソースの生化学的特性調査 Biochemical characterization of *Allium* bioresources under environmental stress in arid field		
共同研究要旨 Summary of Joint Research	In previous cooperative research project (2020-2021), conventional cultivation trial in summer and stress cultivation trial with controlled irrigation were conducted in *Allium* bioresources and some lines showed highly adaptable to environmental stress (high temperature and drought). In this study, the chemical contents of the resources were investigated. The freeze-dried powder from leaf sheath and root portion in each line obtained from previous trials was subjected to LC-MS/MS analysis, which obtained information on 56 and 62 metabolites in the root and leaf sheath, respectively. Among the metabolites, methionine sulfoxide, betaine, proline, *β*-alanine, choline, guanosine, and cytidine were found to be more abundant in the root under stress cultivation than under conventional, and there was a positive correlation between each content and plant weight. It is suggested that under environmental stress conditions, *Allium* plants maintain tissue homeostasis by increasing the production capacity of these metabolites. Furthermore, the pectin (EtOH-P, W-P, HM-P, HCl-P, and NaOH-P) in the leaf sheaths of the plants showed different production levels among lines under stress condition. Pectin is known to play role in strengthening cell to cell bonds. it is possible that external stimuli from the harsh environmental stress enhanced cell wall pectin production and caused physical structural changes. Normally, onion (shallot) forms outer leaf (called a protective leaf) and go dormant during summer season. it is possible that genes that convert pectin into more solid carbohydrates such as lignin in vivo are present on the shallot chromosome. In this study, we have gained some understanding of the biochemical characteristics of *Allium* plants during abiotic stress cultivation.		

一般研究 7 General Research 7		対応教員 Corresponding Staff	藤巻　晴行 Fujimaki, Haruyuki
研究代表者 Principal Researcher	澤　進一郎（熊本大学大学院先端科学研究部） Sawa, Shinichiro (Faculty of advanced science and technology, Kumamoto University)		
研究課題 Research Subject	農業用資材としての酸化グラフェンの機能解析 Functional analysis of graphene oxide for agriculture		
共同研究要旨 Summary of Joint Research	In arid regions, it is difficult to secure sufficient water resources for crop cultivation due to low precipitation, and irrigation or improvement of soil water retention is essential for agriculture. Graphene oxide is synthesized by oxidizing graphite, so the graphene surface is negatively charged with oxygen atoms, hydroxyl groups, or carboxyl groups, and forms complexes with various cationic substances. It is also known to adsorb water molecules. Therefore, in this study, the function of graphene oxide was verified with the aim of using it as a water retention material in agriculture. In FY2022, we were allowed to use a field at the Arid Land Research Center of Tottori University to verify the water retention function of the water retention agent using soil columns. In this test, pots with a diameter of 20 cm and a height of 1.5 m were used. We purchased vinyl chloride pipes at a home improvement store and made this pot by ourselves. For the pot, dune sand (untreated) from the Tottori University Dune Research Institute and fresh sand soil were used as soil samples and filled into the pot. Using a jumbo, these large pots were filled in the field and soybeans were sown at the tops of the pots. These soil samples were infiltrated with 10 mg/L graphene oxide as a water retention agent and used in the tests. Three replicates (for three plants) were tested together with a control experimental plot to which graphene oxide was not added. The results showed that the water retention test was appropriate because of the poor growth in the dune sand compared to the fresh sand soil. When grown in dune sand, the experimental plot with graphene oxide added had heavier plant weights, suggesting that graphene oxide may be effective as a water retention agent.		

一般研究 8 General Research 8		対応教員 Corresponding Staff	黒崎　泰典 Kurosaki, Yasunori
研究代表者 Principal Researcher	石塚 正秀（香川大学創造工学部） Ishizuka, Masahide (Faculty of Engineering and Design, Kagawa University)		
研究課題 Research Subject	大陸から越境する黄砂と発生域のゴビ砂漠における黄砂の観測 Observations of transboundary Asian dust and dust from the source area in the Gobi Desert		
共同研究要旨 Summary of Joint Research	Transboundary Asian dust (KOSA) was observed in Takamatsu City, Kagawa Prefecture on May 2021. The observation was carried out for three days from 18:00 on May 7, 2021 to 17:00 on May 10, 2021 JST on the roof of the building on the Hayashi-machi Campus of Kagawa University. An optical particle counter (OPC) (GT526S, Shibata Inc.) and a compact, power-saving sensor (PMSA003i, Plantower) were used. In order to understand the distribution of Asian dust over a wide area, we used Dust RGB from Himawari-8, reanalysis data v5 (ERA5) from ECMWF, and dust extinction coefficients from the Asian Dust and Aerosol Observation Network (AD-Net) from LIDAR (Light Detection And Ranging). On the night of May 5, 2021 (JST), dust was generated by low pressure L1 centered in eastern Mongolia and the accompanying cold front, and moved to the east of the Korean Peninsula at 21:00 JST on the 7th (Fig.1a). According to the AD-Net results, dust was observed in South Korea from the afternoon of the 7th to the morning of the 9th (peak at midnight on the 7th), and in Japan from the night of the 7th to the night of the 9th (peak at noon on the 9th). In Takamatsu City, strong westerly winds of 5.8-8.1 m/s (7-18h JST) were observed for 11 hours due to the passage of a cold front associated with low pressure L2 around 9:00 JST on the 9th (Fig.1b). Correspondingly, airborne particle concentration by OPC and PMSA003i increased (Fig.2). At this time, an increase in SPM concentration was observed throughout Kagawa Prefecture (Fig.2). According to observations by the Japan Meteorological Agency, dust (KOSA) was not observed in Takamatsu in FY2022, and there was no Transboundary Asian dust. Fig.1 left: Himawari-8 Dust RGB (pink color shows dust), ERA5 sea level pressure, 850 hPa wind distribution. Half and full wind arrows represent wind speeds of 2.5 and 5 m/s, respectively. The yellow lines indicate the positions of the cold fronts associated with Low pressure 1 (L1) and Low pres		

	sure 2 (L2). Center: Air temperature at 850 hPa and sea level pressure by ERA5, Right: True color RGB distribution of Himawari-8. Fig.2 Atmospheric airborne particulate concentration (mass conversion) and temporal variations of SPM concentration (JST) (bold blue line: OPC, bold orange line: PMSA003i, thin lines: SPM concentration at 21 points in Kagawa Prefecture) (Herein, OPC and PMSA have been converted to correction coefficients.)

一般研究 9 General Research 9		対応教員 Corresponding Staff	安　萍 An, Ping
研究代表者 Principal Researcher	松浦 朝奈（信州大学農学部） Matsuura, Asana (Faculty of Agriculture, Shinshu University)		
研究課題 Research Subject	塩ストレス下における雑穀のナトリウム蓄積低減機構の解析 Reduction mechanism of sodium accumulation of millet under salt stress		
共同研究要旨 Summary of Joint Research	Four kinds of millets were hydroponically cultivated, and cultivated until harvest in a salt water section in which the culture solution was adjusted to a NaCl concentration of 150 mM on the 30th day after sowing, and in a control section in which the culture solution was used alone. Salt tolerance was determined by calculating the stress sensitivity index from the plant growth rate during the treatment period. The xylem water potential of leaf was measured 30 days after treatment. Three days after the treatment, adventitious roots of 10-15 cm in length were harvested, and cross-sections of the roots were made every 1 cm from the root tip to observe suberin accumulation in the hypodermis and endodermis. Furthermore, the collected plants were decomposed into individual organs and dried, and Na and K were analyzed with an atomic absorption photometer, and nitrogen was analyzed with a CN coder (Equipment of Arid Land Research Center). From the stress sensitivity index, it was confirmed that E. tef is more salt tolerant than E. utilis, B. ramosa and S. italica. Salt damage induces water stress and ionic stress in plants. The degree of water stress in plants was measured as the water potential of leaves. The result showed that no interspecific ddifferences was observed. Sodium uptake in E, tef and B. ramosa were lower than that in E. utilis and S. italica. The relationship between suberin accumulation in endodermis and salt tolerance was unclear. On the other hand, suberin accumulation in the hypodermis did not change in salt-tolerant E. tef, but suberin accumulated far from the root tip in the other three species after salt treatment. These findings suggest that the salt tolerance of the four millets is related to the difference in the accumulation pattern of suberin, which is involved in sodium absorption, in the hypodermis of the roots.		

一般研究 10 General Research 10		対応教員 Corresponding Staff	寺本　宗正 Teramoto, Munemasa
研究代表者 Principal Researcher	永野　博彦（新潟大学自然科学系） Nagano, Hirohiko (Institute of Science and Technology, Niigata University)		
研究課題 Research Subject	水溶性有機物に基づく海岸砂丘土壌の有機物分解動態の推定 Water-extractable organic matters for elucidating organic matter decomposition in coastal soils		
共同研究要旨 Summary of Joint Research	In this study, we analyzed the water-extractable organic matter (WEOM) that can be collected by water extraction from the air-dried soil of the coastal sandy soil, in order to investigate soil organic matter (SOM) decomposition (i.e., substrate and decomposition characteristics) by microorganisms in a low-carbon (C) soil environment. In previous preliminary studies in Japanese forest soils, we have found that the WEOM from air-dried soil is likely derived from microbial cells. Although sandy soil is widely distributed along the 35,000 km coastline of Japan, the SOM decomposition in these areas has been less elucidated. This study is also expected to contribute to soil C dynamics in arid land ecosys-tems. In the first year of the two-year plan, we surveyed coastal sandy soils around the Arid Land Research Center of Tottori University, where Dr. Teramoto is conducting soil CO_2 emission monitoring, and other coastal sandy soils around Niigata University, where the applicant belongs. In these sandy coastal areas, we collected sandy soils and prepared them for further analysis. Sandy soils (from 0 to 30 cm in depth) in Tottori were collected from 12 plots with different levels of vegetation coverage. Their C and nitrogen (N) concentrations of WEOM have been measured, and the data are being analyzed. The WEOM concentration of Tottori soils was 42 ± 9 μg/g dry soil in terms of C content and 30 ± 12 μg/g/g dry soil in terms of N content, resulting to 1.4±0.3 as C/N ratio. These concentrations		

	are less than 1/10 of those reported for forest soil in Japan, and are thought to reflect the low organic matter content and organic matter decomposition activity in coastal sandy soils. In next year, we will proceed with similar sample preparation and analysis for coastal sandy soils in Niigata, and establish a foothold for clarifying C dynamics in coastal sandy soils and arid land soils having low C concentration.

一般研究 11 General Research 11		対応教員 Corresponding Staff	安　萍 An, Ping
研究代表者 Principal Researcher	杉本　幸裕（神戸大学大学院農学研究科） Sugimoto, Yukihiro (Graduate School of Agricultural Science, Kobe University)		
研究課題 Research Subject	宿主における発芽刺激物質の生産制御による根寄生雑草防除法の構築 Root parasitic weed management by decreasing seed germination stimulant production in host plants		
共同研究要旨 Summary of Joint Research	Strigolactones (SLs) are plant apocarotenoids with diverse functions and structures. The widespread, structurally diverse canonical SLs are classified into strigol and orobanchol types based on their tricyclic lactone C-ring configurations. Molecular mechanisms of their stereoselective control are not fully understood. We previously demonstrated that SlCYP722C from tomato (*Solanum lycopersicum*), which produces orobanchol type SLs, is involved in the conversion of carlactonoic acid (CLA) to orobanchol. However, *in vitro* assay showed that the enzyme produced not only orobanchol but also its diastereomer, *ent-2'-epi*-orobancho, which is not detected in tomato. We conducted detailed biochemical analysis of SlCYP722C to elucidate the mechanism of the BC-ring formation in orobanchol. SlCYP722C was heterologously expressed in *Escherichia* coli and then chromatographically purified. Enzyme assay using the recombinant protein yielded 18-oxo-CLA, which was spontaneously cyclized to generate orobanchol and its diastereomer. These results suggested involvement of another enzyme in orobanchol biosynthesis that catalyzes the stereoselective BC-ring closure reaction of 18-oxo-CLA in tomato. We identified the enzyme designated orobanchol synthase (OS), which resulted in exclusive formation of orobanchol from 18-oxo-CLA. Signal peptide of OS and SlCYP722C were fused with fluorescent protein and transiently expressed in *Nicotiana benthamiana* leaves using Agrobacterium infiltration. Fluorescent images indicated co-localization of OS and SlCYP722C at ER, which may facilitate metabolic channeling.		

一般研究 12 General Research 12		対応教員 Corresponding Staff	黒崎　泰典 Kurosaki, Yasunori
研究代表者 Principal Researcher	大西　一成（聖路加国際大学大学院公衆衛生学研究科） Onishi, Kazunari (Graduate School of Public Health,Environmental Health, St.Luke's International University)		
研究課題 Research Subject	モンゴルにおけるダスト及び乾燥地の環境が及ぼす健康影響 Adverse health effect of Asian dust and arid environment in Mongolia.		
共同研究要旨 Summary of Joint Research	The health effects of Asian dust (AD: mineral dust) originating from arid areas such as the Gobi Desert and the Taklamakan Desert are a concern. The purpose of this study is to conduct a health impact survey on Mongolian residents, who are likely to be exposed to high levels of AD, and to contribute to the improvement of their quality of daily life based on the findings. With reference to the ethical guidelines of recent epidemiological studies on human subjects in Japan, it is being considered and prepared to conduct an ethical review or equivalent assessment in Mongolia, where the participants live. After this review, data cleaning will continue to be conducted to scrutinize and analyze the regional and seasonal impacts. The questionnaire survey was conducted on the prevention behavior of subjective symptoms (nasal, ocular, respiratory, skin, fever, headache, stress) and the situation of going out of the house using the self-report system of paper. It was conducted from October 2018 to October 2021. The total number of participants was 356. In sex- and age-adjusted analyses, significant strong relationships were found between AD and the following symptoms: Nasal ($p = 0.001$), respiratory ($p = 0.002$), throat ($p = 0.022$), skin symptoms (Exposed: $p = 0.004$, Covered: $p = 0.045$), and headache ($p = 0.002$). There have been reports of skin symptoms caused by AD, which has been attributed to physical irritation of exposed areas. The effect of the skin on the covered area was also significant, suggesting an allergy due to high internal exposure. The threshold value for the extinction coefficient of LIDAR at which these symptoms appear was		

	0.0035/km (Mongolia) for both AD (non-spherical) and air pollutants (spherical). In our study in Japan, LIDAR AD days and JMA judged AD days were evaluated using ROC curves, and as a result, the extinction coefficient AD (non-spherical), more than 0.0355/km, was defined as AD days. We found that even with much lower LIDAR values, symptoms appeared with long-term exposure in Mongolia.

一般研究 13 General Research 13		対応教員 Corresponding Staff	恒川　篤史 Tsunekawa, Atsushi
研究代表者 Principal Researcher	土本　卓（大阪大学大学院薬学研究科） Tsuchimoto, Suguru (Graduate School of Pharmaceutical Sciences, Osaka University)		
研究課題 Research Subject	乾燥地における高収量・高品質の油脂生産のための研究 Research for oil production with high quantity and quality in the arid land		
共同研究要旨 Summary of Joint Research	Jojoba is a commercial fruit tree, originated from Sonoran desert, suitable for arid areas that can be grown with a small amount of irrigation water and produces a valuable non-edible oil in its seeds. We received jojoba cuttings from the USDA in 2015, and have been conducting jojoba research. In 2017, we started a trial cultivation of jojoba on a 4.2 ha farm in Egypt (Beheira). Approximately 5,000 jojoba plants (4,000 female cuttings and 1,000 seedlings for pollen supplies) are cultivated. In 2020, to select jojoba plants with high yield from them, 173 elite plants with good growth and high fruit density, as well as 36 average plants were selected from the female cuttings. We measured their height and seed yield in 2020 and 2021. In this study, we measured the tree height and seed yield of the selected plants in 2022, and compared the data for the three years from 2020 to 2022. The results showed that the tree height increased significantly every year, and that the elite plants had significantly higher seed yields than the average plants. A positive correlation was found between tree height and seed yield, but the correlation was weak in populations of high-yielding plants. A number of plants have been found to be ranked in the top 10 in terms of seed yield for three consecutive years. From the next fiscal year onwards, we will narrow down elite plants that will stably produce high yields. We are also conducting research on jojoba clone propagation by tissue culture for efficient vegetative propagation of elite plants. We investigated the conditions for efficient shoot elongation and rooting. Furthermore, two papers have been published on the characteristics of jojoba oil extracted from the seeds of the same farm, showing that unrefined jojoba oil had both high oxidation stability and antioxidant activity, and was resistant to oxidative deterioration even when subjected to heat treatment, and had no cytotoxicity after the treatment. In addition, the USDA jojoba strains are being maintained at the ALRC and Osaka University.		

一般研究 14 General Research 14		対応教員 Corresponding Staff	山中　典和 Yamanaka, Norikazu
研究代表者 Principal Researcher	衣笠　利彦（鳥取大学農学部） Kinugasa, Toshihiko (Faculty of Agriculture, Tottori University)		
研究課題 Research Subject	モンゴルにおける晩霜害リスクと温暖化 Effect of global warming on the late-spring frost risk in Mongolia		
共同研究要旨 Summary of Joint Research	Late-spring frost damage is a natural disaster damaging juvenile plants due to sudden frozen temperature in early spring, and it damages wide range of grassland vegetation. Global warming is suggested to advance plant phenology, and consequently expand late-spring frost damages. As Mongolia depends largely on pastoralism for its economy and food supply, it is important to understand the future changes in the risk of late-spring frost damages on grassland plants. Thus, we analyzed the long-term monitoring data in Mongolia to demonstrate the changes in the risk of late-spring frost damage until now. We finally aimed to test the contribution of global warming on the changes in the risk of late-spring frost damage in Mongolia. Data of daily mean temperature and minimum temperature in the period from the beginning of the year to the end of June for past 40 years were obtained from Information and Research Institute of Meterology, Hydrology and Environment for 70 weather stations across Mongolia. After removing missing values and abnormal values, the risk of late-spring frost damage was calculated after Zohner et al. (2020). In their method, risk of frost damage was defined as the degree days (>0ºC) that was accumu-		

	lated for the period from the begging of the year to the day of last frost (defined as the day when minimum temperature was below 0ºC in spring). We calculated the temporal changes in the risk of late-spring frost damage over past 40years across Mongolia, and found that the risk of frost damage tended to increase in these 40 years except for in the north part of Mongolia (Fig. 1). Interestingly, the risk of frost damage was rather decreasing in the north region. We then calculated the temporal changes in the mean annual temperature across Mongolia, and showed that the warming tendency was found over Mongolia. In the next year, we are going to analyze the factors causing the spatial difference in the temporal changes in late-spring frost risk and test the contribution of warming to the changes in the risk of frost damage.

一般研究 15 General Research 15		対応教員 Corresponding Staff	山中　典和 Yamanaka, Norikazu
研究代表者 Principal Researcher	岩永　史子（鳥取大学農学部） Iwanaga, Fumiko (Faculty of Agriculture, Tottori University)		
研究課題 Research Subject	西部中央アジア乾燥地の塩生植物の耐塩性機構 Characteristics of salt tolerance in halophytes growing in the Western-Central Asian arid area		
共同研究要旨 Summary of Joint Research	To investigate the adaptability to environmental stresses of the dominant halophytes of arid area in western Central Asia, we investigated the salt tolerance of one of the *Climacoptera* spp. The germination and growth characteristics of this species under salt conditions were clarified using seeds collected from field-grown individuals of the target species and brought back in 2020. Seven levels of salt concentration (0, 100, 250, 500, 750, 800, and 850 mM) were prepared for germination conditions. Petri dishes containing 50 seeds were placed in incubators under constant 24°C, and the number of germinated seeds was counted until 10 days after sawing. Finally, the germination rates were almost 100% from 0 to 500 mM, but the germination rate above 750 mM decreased with increasing salt concentration (Figure 1A). In addition, no increase in germination rate was observed at 7 days after sowing in any of the treatments. Root length of germinated seedlings also tended to decrease with increasing salt concentration (Figure 1B). At the end of the germination experiment, the seedlings obtained were grown and used in the salt treatment experiment. Seedlings from germination conditions of 0 mM, 100 to 250 mM (300mM), and 500 mM, were divided into three groups and grown in 0, 300, and 500 mM salt water irrigation for one month. The dry weight of seedlings tended to increase as the salt concentration increased, indicating the salt-favor characteristics of this species. The higher the salt concentration of germination conditions, the higher the total dry weight at the end of the growing experiment (Figure 2). This suggests that salinity conditions during germination affect salt tolerance during the subsequent growth period.		

一般研究 16 General Research 16		対応教員 Corresponding Staff	藤巻　晴行 Fujimaki, Haruyuki
研究代表者 Principal Researcher	齊藤　忠臣（鳥取大学農学部） Saito, Tadaomi (Faculty of Agriculture, Tottori University)		
研究課題 Research Subject	安価な GNSS 信号受信システムを用いた土壌水分推定手法の開発 Development of soil moisture estimation method using inexpensive GNSS signal reception system		
共同研究要旨 Summary of Joint Research	Surface soil moisture is a key component of the water cycle. Larson et al. (2008) indicated one of the new soil moisture content (SMC) sensing methods in the hundred meters of spatial scale. This method is also known as Global Navigation Satellite System Reflectometry (GNSS-R), which demonstrates the data derived from the Global Positioning System (GPS) receivers can be used to the measurement of soil moisture content. The objective of this study is to demonstrate the possibility of SMC measurement using low-priced GPS/GNSS receivers. Two experimental sites were established in Tottori University Arid Land Research Center (ALRC) and Filed Science Center (FSC). We developed the device to extract the data from GNSS receivers by combining low-priced micro computer and GNSS receivers. We also developed the software to analyze Signal-to-Noise Ratio (SNR) data which is affected by surface soil moisture. As the results, reflection height (H) of analyzed data from selected 4 GPS satellites in FSC showed		

	relatively high correlation with SMC measured by the dielectric sensors. SMC can be estimated by substituting H for the linear regression equation obtained. These results suggesting that combination of low-priced micro computers and GNSS receivers can be a tool to estimate surface soil moisture.

一般研究 17 General Research 17		対応教員 Corresponding Staff	辻本　壽 Tsujimoto, Hisashi
研究代表者 Principal Researcher	石原　亨（鳥取大学農学部） Ishihara, Atsushi (Faculty of Agriculture, Tottori University)		
研究課題 Research Subject	イネ科植物における環境および生物学的ストレスが脂質代謝に及ぼす影響 Effects of environmental and biological stress on lipid metabolism in grasses		
共同研究要旨 Summary of Joint Research	In plants, lipid metabolism plays a major role in defense responses to various stresses. For example, oxylipins are synthesized from fatty acids and accumulated in response to the stresses. However, the source of fatty acids used for oxylipin synthesis has not been clarified. Recently, we showed that lysoglycerolipids, in which one acyl group is released from glycerolipids, accumulate when barley leaves are infected by pathogens. This finding suggests that glycerolipids are degraded into fatty acids and lysoglycerolipids upon pathogenic infection, and oxylipins are synthesized from free fatty acids. In this study, we analyzed the kinetic changes in various classes of lipids to elucidate the lipid-mediated stress response mechanism against pathogens. The accumulation of lysoglycerolipids produced from galactolipids and phospholipids increased simultaneously by 24 hours after inoculation with pathogens. In the analysis of free fatty acids, linolenic acid showed a maximum accumulation at 24 hours after inoculation, whereas linoleic acid showed a maximum accumulation at 96 hours. In the analysis of oxylipins, jasmonic acid and 12-oxo phytodienoic acid, a precursor of jasmonic acid, increased 12 to 48 hours after inoculation. In contrast, oxo-octadeca-10, 12-dienoic acid (KODE) reached at the maximum accumulation 96 hours after inoculation, indicating a time lag in accumulation among fatty acids and oxylipins. Lysoglycerolipids derived from galactolipids and phospholipids increased almost in parallel, suggesting that free fatty acids from both lipids are used for the synthesis of oxylipins. In contrast, free fatty acids and oxylipins increased at different timings depending on their molecular species. Thus, these compounds are presumed to play different roles in the defense response of barley leaves.		

一般研究 18 General Research 18		対応教員 Corresponding Staff	藤巻　晴行 Fujimaki, Haruyuki
研究代表者 Principal Researcher	猪迫　耕二（鳥取大学農学部） Inosako, Koji (Faculty of Agriculture, Tottori University)		
研究課題 Research Subject	乾燥地域における持続的な塩水灌漑を可能とする圃場水管理 Field water management for sustainable saline water irrigation in dryland		
共同研究要旨 Summary of Joint Research	The objective of this study was to clear the behavior of salts and water in soil when saline surface irrigation was conducted to the subsoil with low salinity by precise experiments in a soil column and numerical experiments. A 20 cm thick gravel layer was placed at the bottom of a 2.7 x 2.8 x 0.9 m bottomless rectangular soil column to form a capillary barrier layer, which was then filled with sandy loam to a thickness of 50 cm. Soil moisture and salinity were measured with TDR sensors buried horizontally at 5, 15, 25, and 35 cm from the surface. The irrigation water was a multi-component saline water adjusted to 5 dS/m. Irrigation was carried out using a drip tube for 20 minutes after the matric suction reached 98 kPa at a depth of 15 cm in the soil layer. The experiment was conducted from October to December. The results showed that after irrigation with freshwater (0.11 dS/m) before the start of the experiment, the salinity in the shallow surface layer increased, but there was no significant increase in the salinity in the area corresponding to the crop root zone. The EC of the soil pore water to the lower layers remained lower than that of the irrigation water, suggesting an initial dilution effect of the fresh water. Small soil evaporation may be another factor that contributed to these results. Numerical experiments using HYDRUS 2D/3D were conducted to analyze the diffusion of salts in soil by drip irrigation with saline. The initial salinity of the soil was set to be low (equivalent to 0 dS/m)		

	and slightly high (equivalent to 1 dS/m). 5 dS/m of saline water was supplied at 15 mm per hour for both conditions. Numerical results showed that the saline water supplied to the soil was diluted by the soil water and that the spread of the saline water in the soil was limited.

一般研究 19 General Research 19		対応教員 Corresponding Staff	辻本　壽 Tsujimoto, Hisashi
研究代表者 Principal Researcher	明石　欣也（鳥取大学農学部） Akashi, Kinya (Faculty of Agriculture, Tottori University)		
研究課題 Research Subject	植物細胞壁の構造変化による乾燥地植物の高温ストレス耐性機構の解析 Involvement of structural changes in the plant cell walls in the heat stress tolerance mechanism in arid land plants		
共同研究要旨 Summary of Joint Research	Plant cell walls are known to play important roles in plant morphogenesis, structural maintenance, and biological defense. On the other hand, studies on the environmental stress response of cell walls have been limited. In a previous joint research project with the Arid Land Research Center, we had published a paper discussing the possibility of large-scale structural changes in the cell wall of wheat leaves exposed to high temperature stress, in which significant changes were observed in the mid-infrared (FTIR) spectra of leaves of a wheat cultivar No. 61. In the present study, we first compared several wheat lines using this analytical method. As a result, we found that there were significant differences in FTIR spectra among the lines and that the spectra changed in a line-specific manner under high tem-perature stress (Osman et al., 2022). This technology is expected to be used for breeding of stress tolerant varieties and remote sensing of various crops. In the next experiment, to elucidate molecular basis of cell wall stress behavior, wheat leaves exposed to high temperature stress were chemically fractionated, and the FTIR spectra of each fraction were compared and analyzed for cell wall monosaccharide composition. We found that a spectrum for pectin- and mixed-linkage β-glucan (MLG)-fraction showed significant spectral changes, and that the monosaccharide composition of this fraction was altered under high temperature stress. Pectin is a soluble polysaccharide consisting of more than 10 monosaccharides, and MLG is composed of β-glucose with β1,3 bonds in every 3-4 units, forming a highly plastic polysaccharide structure with low crystallinity. Pectin and MLG are present in plant cell walls to fill the spaces between cellulose fibers, and are known to maintain cell adhesion and tissue flexibility, as well as to regulate the permeability of plant tissues. These observations suggested heat response of wheat leaves involves dynamic change in physicochemical properties of cell wall component.		

一般研究 20 General Research 20		対応教員 Corresponding Staff	石井　孝佳 Ishii, Takayoshi
研究代表者 Principal Researcher	岡本　龍史（東京都立大学大学院理学研究科） Okamoto, Takashi (Graduate School of Science, Tokyo Metropolitan University)		
研究課題 Research Subject	コムギ - イネ Cybrid 植物の形質評価および乾燥・高温耐性 C4 型光合成植物と三大穀物間の Cybrid 作出 Trait evaluation of wheat-rice cybrid plants and production of cybrids between drought/high temperature tolerant C4-type photosynthetic plants and three major crops		
共同研究要旨 Summary of Joint Research	【Trait evaluation of wheat-rice cybrid plant lines】 F3 generation DZ1A, DZ1B, DZ1C, WWR2A, WWR A, WWR3B, WWR3D and F4 generation DZ2A, DZ2B, DZ2C, DZ2D, DZ2E, WWR 1C, WWR2B and WWR3C were each sown in the Arid Land Research Centre plots. Data on agronomic traits such as ear emergence date, flowering date, leaf length/width, stem diameter, ear length, grass height, percentage of berries, dry weight, thousand grain weight and SPAD, as well as photosynthetic capacity such as photosynthetic rate, stomatal conductance and chlorophyll fluorescence were collected. Inter-strain differences were identified in the date of ear emergence (Fielder ,153 days; DZ1B and 1C, 147 to 156 days; WWR3B and 3D, 152 to 172 days). In addition, WWR3B and 3D showed greater leaf length, leaf width and stem diameter than Fielder. 【Generation of cybrid plant between wheat-C4 grass plants】 Allopolyploid zygotes were generated by fusion of wheat egg cell, wheat sperm cell and maize egg cell, and by fusion of wheat egg cell, wheat sperm cell, maize egg cell and maize sperm cell. Allopolyploid zygotes between wheat and pearl-millet were also produced. By culturing them, These allopolyploid zygotes were successfully developed and differentiated into wheat-maize and wheat-pearlmillet		

	hybrids. Genomic DNA has now been extracted from these plants and is being prepared for sequencing.

一般研究 21 General Research 21		対応教員 Corresponding Staff	辻本　壽 Tsujimoto, Hisashi
研究代表者 Principal Researcher	菅野　明（東北大学大学院生命科学研究科） Kanno, Akira (Graduate School of Life Sciences, Tohoku University)		
研究課題 Research Subject	海浜植物ハマタマボウキにおける塩ストレス耐性の分子機構 Molecular mechanism of salt tolerance in *Asparagus kiusianus*		
共同研究要旨 Summary of Joint Research	*Asparagus officinalis* and *A. kiusianus* plants were cultivated on the plastic pots with soil. After we removed the soil and the roots were washed with water, the roots were soaked in NaCl solution (0, 300 mM) for different time (0, 24 hours). After salt treatment, total RNAs were extracted from these samples and cDNA pool were prepared. As a result of gene expression analysis using real-time PCR, the expression of *SOS1* gene and *Plasma membrane ATPase* gene were upregulated in cladodes and roots of both species under the salt stress condition. The expression level of *SOS1* gene in cladodes and roots of *A. kiusianus* was about 2.5 times higher than that of *A. officinalis*. These results indicated that the SOS pathway responded to salt stress and excreted harmful Na+ from the cytoplasm in both species. In addition, it is likely that constant higher expression of *SOS1* gene is the cause the adaptation of the coast habitat in *A. kiusianus*. Furthermore, RNA-seq analysis was performed using the total RNA extracted from the samples used above. Using the same sample above, the proline content in cladodes and roots was analyzed by LC-MS. The proline content of cladodes was higher than that of roots in both species. The proline content was higher in *A. kiusianus* than in *A. officinalis* under salt and non-salt condition. This suggested that *A. kiusianus* might regulate the intracellular osmotic pressure by proline accumulation and adapted to the salt-stressed environment like coast.		

一般研究 22 General Research 22		対応教員 Corresponding Staff	山中　典和 Yamanaka, Norikazu
研究代表者 Principal Researcher	小長谷 有紀（国立民族学博物館人類文明誌研究部） Konagaya, Yuki (Department of Modern Society and Civilization, National Museum of Ethnology)		
研究課題 Research Subject	古写真を用いた環境問題研究 Analyzing Old Photographs for Environmental Study		
共同研究要旨 Summary of Joint Research	In order to conduct a field survey in response to the increasing availability of overseas travel, we decided to limit the survey to the urban landscape of Ulaanbaatar, and to select sites where the approximate location was known. (1) August field survey Using the Grant-in-Aid for Scientific Research “Reconstruction of Regional Image Using Image Records on Mongolia” (Representative: Konagaya) and“Research on Settlement Houses with Practice of Housing Improvement in Mongolia” (Representative: Yatsuo) and the Bunkyo University Research Grant, Konagaya, Hotta, Yatsuo, and Watanabe traveled to Ulaanbaatar Mongolia. With local resident member Takiguchi together, we were able to determine the locations of several old photographs that had been selected. By taking current photos at the same locations with almost same angle, we succeeded in collecting materials for “repeat photography”. (2) September-November meeting After gathering to organize the photos taken at the site, we held zoom meetings. The story map (a method of presenting photos on a map) was created by McCarthy, who lives in the U.S., to present the old and new photos in contrast, with as much of the same perspective as possible. (3) December Presentation Using the above-mentioned results, we attended the annual meeting and won an award for outstanding presentation. The method of presenting old and new photos on a map in contrast is highly universal and can be used for various area studies, and thus was highly anticipated. (4) January-March discussion Satellite imagery purchased for this study was inserted into the story map described above, and we can compare old and new images over much wider area. In addition to the zoom, we held the meeting in person with McCarthy during his stay in Japan to discuss how utilize satellite imagery		

	and drawn maps with varying degrees of accuracy as a future challenge.

一般研究 23 General Research 23		対応教員 Corresponding Staff	石井　孝佳 Ishii, Takayoshi
研究代表者 Principal Researcher	吉田　健太郎（京都大学大学院農学研究科） Yoshida, Kentaro (Graduate School of Agriculture, Kyoto Univresity)		
研究課題 Research Subject	超耐乾・耐暑性作物パールミレットの高度利用化に向けた基盤技術の開発 Development of biotechnology for advanced utilization of drought- and heat-tolerant crop, pearl millet		
共同研究要旨 Summary of Joint Research	To develop mutant lines of pearl millet, 451 individuals of the M2 generation of IPno's 17956 line treated with ethyl methanesulfonate (EMS) at Kyoto University and 1,875 individuals including the M1 and M2 generations of IPno's 17956 line treated with heavy ion beam were planted in sandy plots at the Arid Land Research Center. We identified early flowering mutants, dwarf mutants, and partially sterile mutants. Pearl millet has dry and freeze-tolerant pollens. Inter-subfamily crosses between pearl millet and wheat cause aberrant reproductive process, generating haploid wheat. By utilizing these unique characteristics of pearl millet, we will develop a new technology to enable genome editing in wheat in a single generation, which is difficult to produce transformants. We attempted to establish a stable transformation technology for pearl millet using Agrobacterium, and confirmed that white callus with regeneration ability could be obtained from mature seeds on MS medium containing 3% sucrose and 2,4-D 2.0 mg/L, although the frequency of white callus generation is low. We tried to introduce the green fluorescent protein GFP gene by Agrobacterium transformation into callus. GFP fluorescence in some callus was observed. We also attempted to directly introduce RNPs required for genome editing by CRISPR-Cas9 into pollens or pollen tubes. First, we tested what regents are appropriate for the direct delivery of RNP to pollen tube. We found that pearl millet pollens can tolerate some organic solvents and lipofection reagents and germinate and elongate pollen tubes.		

一般研究 24 General Research 24		対応教員 Corresponding Staff	山中　典和 Yamanaka, Norikazu
研究代表者 Principal Researcher	小田　あゆみ（信州大学農学部） Oda, Ayumi (Faculty of Agriculture, Shinshu University)		
研究課題 Research Subject	野外で採取した土壌試料抽出液中の無機態窒素濃度定量法の改良 Improvement of method for quantifying inorganic nitrogen concentration in soil sample extract collected in the field		
共同研究要旨 Summary of Joint Research	Nitrogen is an essential element for plant growth. Clarifying how plants acquire nitrogen in oligo-trophic environments is important when considering the maintenance of arid land ecosystems. Recently, a simple method has been proposed to extract and quantify nitrogen in soil using a microplate reader. Therefore, we compared and verified the results of the conventional method and several methods of measurement using a microplate reader. Nitrogen was extracted from the same soil sample using the same procedure with three types of ex-tractants (2M KCl, 0.5M K2SO4, and 0.5M NaCl) generally used for nitrogen extraction. The meas-urement methods examined are listed in Table 1 (in the Japanese section). As a result, in order to quantify all forms of nitrogen in a microplate reader, the following methods are suitable: extraction with 0.5M K2SO4, measurement of ammonium by the Berthlot method, nitrate by the vanadium reduction Griess method, and organic nitrogen as nitrate after total oxidation by the POR. Generally, nitrogen in soil is extracted and measured with 2MKCl solution, but when ammonia-form nitrogen was not agree with those of the autoanalyzer depending on the sample. For the measurement of nitrate nitrogen, the absorbance was saturated at concentrations above 200 μM-N. In the case of POR to measure organic nitrogen, KCl and NaCl solutions made precipitates therefore could not be measured in the vanadium reduction Griess method. K2SO4 solution had no precipitates and could be measured. The autoanalyzer was able to measure the extract regardless of the type of extracts after POR.		

一般研究 25 General Research 25	対応教員 Corresponding Staff	安　萍 An, Ping
研究代表者 Principal Researcher	柏木　純一（北海道大学大学院農学研究院） Kashiwagi, Junichi (Graduate School of Agriculture, Hokkaido University)	
研究課題 Research Subject	シンク・ソースバランスに注目した 4 倍体コムギの乾燥抵抗性改善 Improvements for drought tolerance on tetraploid wheat through the sink-source balance	
共同研究要旨 Summary of Joint Research	A main objective of this study was to investigate the relevance of ear photosynthesis (*Pn*) to improve the drought tolerance in wheat. Two tetraploid wheat genotypes with different sink-source balance (Cham-1 with large grain weight, and ET23 with large grain number) were tested. Main results and discussions ・The grain yields were declined when the ear photosynthesis (*Pn*) were suppressed, and the significant G x E were detected. ・Canopy *Pn* were dropped as the ear *Pn* were suppressed, and the G x E were significant. These indicate that, ・the ear *Pn* could be an important source function for the grain developments. ・In Cham-1, the ear *Pn* showed more contributions for the grain yield compared to ET23 irrespective of soil-water environments. ・In ET-23, especially, the stored photoassimilates remobilization for the grain developments was enhanced when the ear *Pn* suppressed. In addition, this genotype didn't show much reduction of flag leaf *Pn* even the ear *Pn* was blocked. This indicates that, ・ET-23 (large grain number type in the sink) could not much rely on the ear *Pn* as it had "compensation functions"for the grain developments. ・Cham-1 (large grain weight type in the sink) could have the conservative systems for the grain filling. Conclusion The ear photosynthesis (*Pn*) could be a potential new source to improve the drought tolerance in wheat (～ 15-24%).	

一般研究 26 General Research 26	対応教員 Corresponding Staff	辻本　壽 Tsujimoto, Hisashi
研究代表者 Principal Researcher	武田　真（岡山大学資源植物科学研究所） Taketa, Shin (Institute of Plant Science and Resources, Okayama University)	
研究課題 Research Subject	コムギ長葉毛遺伝子の単離と発現解析 Cloning of a long hairy leaf gene in wheat and its expression analysis	
共同研究要旨 Summary of Joint Research	The long hair in the leaves of wheat is considered to be one of adaptive morphological factors that could elevate drought resistance under cultivation in arid and high temperature empowered stressful environments. In this investigation, we attempted molecular cloning and morphological characteriza-tion of Chinese landrace wheat, Hong-Mnag-Mai (Kobo-mugi), which express practical adaptation to drought conditions in Loess Platau in China. We have utilized the two pairs of near isogenic lines which differ in the presence or absence of the *Hairy Leaf 2 (Hl2)* gene on the short arm of 7B chromosome that had been reported by the principal investigator decades ago (Taketa et al. 2002 Euphytica). These two pairs of near isogenic lines (RILs) were original materials that were developed by the principal investigator by repeated backcrosses and appropriate morphological selections, and fixed as ho-mozygotes after eight times of backcrosses and subsequent selfing for four generations. We first attempted microsatellite marker mapping of *Hl2/hl2* genes using public wheat SSR markers. The *Hl2* gene was mapped on the 28.1-cM interval in the short arm of chromosome 7B. DrT sequencing of the two RIL pairs has been conducted at the Arid Center, Tottori University. Strong candi-	

	date genes for *Hl2* have already been identified. Currently, validation of the candidate gene(s) is under the way toward preparing a joint publication between Okayama University and Tottori University. We anticipate to submit the manuscript to an influential international scientific journal.

一般研究 27 General Research 27		対応教員 Corresponding Staff	辻本　壽 Tsujimoto, Hisashi
研究代表者 Principal Researcher	野副　朋子（明治学院大学教養教育センター） Nozoye, Tomoko (Center of Liberal Arts, Meiji Gakuin University)		
研究課題 Research Subject	タルホコムギの多様性導入による乾燥地の塩類集積土壌で生育可能なパンコムギの創生 Generation of bread wheat which are tolerate to the alkaline salt affected soil in drought climate area		
共同研究要旨 Summary of Joint Research	Iron (Fe) deficiency in drylands is a common problem preventing crop productivity and quality. In this study, SPAD (Soil & Plant Analyzer Development) values of the newest Fe deficient leaves, metal (Fe, copper (Cu), Zinc (Zn), and Manganese (Mn)) concentrations in leaves, 25 kinds of phenylamides and 2 kinds of phytoalexins in Fe deficient roots and DMA secretion amounts from Fe deficient roots of *Aegilops tauschii* were analyzed to investigate the physiological traits in Fe homeostasis of 42 kinds of *Ae. tauschii*, tetraploid wheat cultivar 'Langdon' and hexaploid wheat cultivar 'Norin61'. In all analyzed trails, there was diversity among the accessions in *Ae. tauschii*. In *Ae. tauschii*, deoxymugineic aid (DMA) was the main mugineic acid family phytosiderophore secreted from the roots, although additional small peaks were detected in some accessions. Among the analyzed compounds, 15 kinds of phenylamides and 2 kinds of phytoalexins were detected in the roots of Ae. tauschii. The Fe concentrations in leaves were positively correlated with SPAD value and Zn, Cu, and Mn concentrations in the leaves, and negatively correlated with DMA secretion amounts from the roots. It was speculated that the susceptibility to Fe deficiency varied among the accessions since SPAD values or DMA secretions amounts were increased or decreased, respectively, following the Fe deficiency levels. In addition, the Fe concentration in leaves was positively correlated with coumaric acid, ferulic acid, and 2 kinds of phytoalexins. Coumarin, biosynthesized from coumaric acid, is reportedly involved in Fe uptake and translocation in plants. Ferulic acid has been reported to act as an oxidant against Fe toxicity in mice. Recently, it was reported that the production of phytoalexins was induced by Fe homeostasis-related transcription factors. It was suggested that coumaric acid, ferulic acid, and phytoalexins are involved in Fe homeostasis in *Ae. tauschii*. It was expected that the candidate genes exist in the Ae. tauschii accessions which could improve the Fe homeostasis of bread wheat.		

一般研究 28 General Research 28		対応教員 Corresponding Staff	谷口　武士 Taniguchi, Takeshi
研究代表者 Principal Researcher	片岡　良太（山梨大学大学院総合研究部） Kataoka, Ryota (Graduate Faculty of Interdisciplinary Research, University of Yamanashi)		
研究課題 Research Subject	内生菌による宿主植物の環境ストレス耐性向上メカニズムの解明 Enhancement of environmental stress tolerant for host plant by endophytic fungus		
共同研究要旨 Summary of Joint Research	Endophytes are microorganisms that infect plants without disease. They are known to have plant growth promoting (PGP) ability and environmental stress resistance to host plants. Leptosphaeria sp. T-2 is an endophytic fungus isolated from barley roots in Japan, and has been shown to infect plant roots and exert PGP effects. In this study, it was confirmed that T-2-infected lettuce had improved resistance to water and salt stress, elongation of roots and roots, and increased fresh and dry weight. In addition, accumulation of ABA, proline, and glycine betaine, which are stress response substances, decreased by T-2 strain infection. Since the plants were stimulated and the stress response substances decreased, it is considered that the stress received by the plants was alleviated. It was confirmed that this result does not contradict the decrease in the moisture content of the above-ground part. Thus, it was confirmed that the effect of Leptosphaeria sp. T-2 on the host plant was to improve the growth promotion effect, water stress tolerance, and salt stress tolerance. ABA, which suppresses the transpiration rate of plants, and compatible solutes, which regulate the osmotic pressure of the cytoplasm, were decreased by T-2 infection, and the moisture content of the above-ground part actually decreased. When the metabolic state of plants was directly measured, water stress reduced the photosynthetic rate and transpiration rate of T-2 strain-infected lettuce. T-2-infected lettuce showed a large amount of transpiration in the whole plant due to the difference in plant size, but there is a contradiction between the de-		

	crease in transpiration rate measured by LI-6800 and the decrease in ABA content. Therefore, further research is needed in the future.

一般研究 29 General Research 29		対応教員 Corresponding Staff	山中　典和 Yamanaka, Norikazu
研究代表者 Principal Researcher	宮沢　良行（九州大学キャンパス計画室） Miyazawa, Yoshiyuki (Campus Planning Office, Kyushu University)		
研究課題 Research Subject	黄土高原に生きる在来樹種の水利用と乾燥への応答の解明 Transpiration characteristics of native tree species in Loess Plateau		
共同研究要旨 Summary of Joint Research	This study aimed to reveal the responses of native pine species in Loess plateau to soil water deficit and/or to the increased atmospheric evaporative demand. Due to the difficulties in travels to China, we investigated the plant water use of the Japanese black pine species. In order to facilitate the measurements by the collaborators in China, we established new and cheap measurement system using recently available micro-computers, rather than the introduction of expensive commercial instruments that require complicate procedures for the maintenance and handling. The established system, by modifying both the sensor and the data collector (data logger), successfully measured the xylem temperatures, which were necessary for the computation of tree sap flux, as the surrogate for tree transpiration. Black pines exhibited the diurnal trends in sap flux, characterized by the increase in the morning, daily peak followed by gradual decrease in late afternoon. Daily peak sap flux increased after spring and reached a peak in mid summer, suggesting that black pine trees supplied water to the needles sufficient for maintaining photosynthesis and the associate water loss as transpiration. Species in both dry and mesic sites are known to fail to meet the increasing water loss by the leaves (and needles) by water supply from the soil via vessels, and restrict transpiration rate by closing stomata, sacrificing photo-synthetic carbon gain. Midday depression in transpiration was, however, not detected, and sap flux increased as the function of the atmospheric vapor pressure deficit. Results indicated that black pine trees could supply sufficient amount of water to the vigorously transpiring leaves and support photo-synthesis as long as the soil I wet. Increased evaporative demand in Loess plateau alone does not depress photosynthesis for drought tolerant pine species.		

一般研究 30 General Research 30		対応教員 Corresponding Staff	安　萍 An, Ping
研究代表者 Principal Researcher	荒木　良一（和歌山大学教育学部） Araki, Ryoichi (Faculty of Education, Wakayama University)		
研究課題 Research Subject	乾燥ストレス下におけるナノ粒子のケイ素がソルガムのミネラル含量に及ぼす影響の評価 Evaluation of the effect of nanoparticle silicon on the mineral content of Sorghum bicolor under drought stress conditions		
共同研究要旨 Summary of Joint Research	Silicon is known to have various stress-relieving effects on crops. However, water-soluble silicic acid is highly alkaline, which is a problem and requires careful application methods. We focused on nano-particle silicon oxide (NP_Si), which does not cause soil alkalinization, and studied its effect on the growth of sorghum under drought stress conditions. In a pot-culture experiment, the sorghum biomass decreased with drought stress treatment, indicating that drought stress affected the sorghum biomass. Under the drought stress conditions, the NP_Si treatment tended to increase ear weight and grain yield as an effect of the NP_Si treatment. Although it was not significant, NP_Si also tended to increase ear weight and grain yield in the 2021 cultivation experiment, suggesting that NP_Si can increase ear weight and grain yield. Furthermore, the initial response of sorghum to iron deficiency was mitigated by NP_Si treatment, indicating the effectiveness of NP_Si treatment in hydroponic culture. In this year, we further focused on salt stress, one of the most important stress factors in semi-arid land, and attempted to verify whether NP_Si has a mitigating effect on salt stress by the hydroponic culture. When the salt concentration was 80 mM, no significant difference in plant height was observed for the NP_Si treatment compared to the 0 mM salt concentration, suggesting that NP_Si improved the growth of sorghum under salt stress conditions. We will elucidate the mechanism of the salt stress mitigation effect of NP_Si in the future.		

一般研究 31 General Research 31		対応教員 Corresponding Staff	藤巻　晴行 Fujimaki, Haruyuki
研究代表者 Principal Researcher	坂口　敦（山口大学創成科学研究科） Sakaguchi, Atsushi (Graduate School of Sciences and Technology for Innovation, Yamaguchi University)		
研究課題 Research Subject	葉温に基づく乾燥ストレス指数推定式の気孔コンダクタンスを指標とした推定精度比較 Accuracy comparison between estimation models of drought stress index based on leaf temperature using stomatal conductance		
共同研究要旨 Summary of Joint Research	Since leaf temperature observations in fields have become easier due to the development and popularization of unmanned aerial vehicles (UAVs), new regional irrigation management systems could be developed based on a crop water stress index (CWSI) map created using UAV thermal images. Developing such a system requires a method of calculating CWSI from thermal images. In addition, since CWSI is an irrigation indicator, the UAV must fly when the CWSI reflects suction in the root zone. Moreover, the UAV must fly several times to mitigate the effect of fluctuations in wind speed and solar radiation. Using observations from a maize field in Kununurra, Australia, we developed a method to estimate mean temperatures of leaves receiving direct sunlight, which enabled us to estimate leaf temperatures with a mean absolute error (MAE) of 0.5°C compared to observed temperatures. The absolute error of CWSI led by this temperature MAE was <0.07. In the method, pixels in a thermal image of a field were considered leaves receiving direct sunlight if the pixel temperature were between the highest and lowest theoretical temperatures of leaves receiving direct sunlight under a given meteorological condition. The highest theoretical temperature of leaves receiving direct sunlight was calculated based on the energy balance, while the lowest theoretical temperature was calculated based on the ratio of leaves receiving direct sunlight. The CWSI of the field was calculated using the mean temperature of pixels, which theoretically had the same temperatures as leaves receiving direct sunlight. For the dry season in Kununurra, the optimal flight time of the UAV was 15 o'clock, with a flight frequency of six at that time estimating CWSI within the MAE of 0.02 to the one-hour mean CWSI.		

一般研究 32 General Research 32		対応教員 Corresponding Staff	木村　玲二 Kimura, Reiji
研究代表者 Principal Researcher	松井　仁志（名古屋大学大学院環境学研究科） Matsui, Hitoshi (Graduate School of Environmental Studies, Nagoya University)		
研究課題 Research Subject	全球モデルを用いたアジアダストの放出頻度と気候影響の高精度化に関する研究 Studies on improved estimation of emission frequency and climate impacts of Asian dust using a global aerosol model		
共同研究要旨 Summary of Joint Research	In FY2021, we improved the estimation of Asian dust emission frequency in our global model CAM-ATRAS and achieved most of objectives of this study. In FY2022, we used this global model to evaluate the climate impacts of Asian dust. In particular, we focused on the effects of ice nucleating particles (INPs) on ice and/or mixed-phase clouds, which are highly uncertain in climate predictions, and evaluated the impacts of Asian dust on the cloud radiative effect through INPs. Asian dust is estimated to have the cloud radiative forcing of about +0.5 W m-2 in East Asia and +0.2 W m-2 in North America and in the Arctic (global average: +0.07 W m-2) through INPs. Asian dust and Sahara dust have similar cloud radiative forcings in East Asia, while Sahara dust has larger cloud radiative forcing than Asian dust in North America and in the Arctic, In our study, we compared our global aerosol model simulations with the arid-region maps over desert regions without vegetation. It is difficult to directly compare the threshold wind friction velocity between the arid-region maps and the model simulations in the regions where vegetation exists because they consider vegetation differently. In future studies, it is important to modify the calculation method of the threshold wind friction velocity in our global aerosol model so that the threshold wind friction velocity in the model can be compared directly with that in the arid-region maps including the regions where vegetation exists.		

一般研究 33 General Research 33	対応教員 Corresponding Staff	木村　玲二 Kimura, Reiji
研究代表者 Principal Researcher	田川　公太朗（鳥取大学農学部） Tagawa, Kotaro (Faculty of Agriculture, Tottori University)	
研究課題 Research Subject	地上設置型太陽光パネル群の配置条件による風速低減効果に関する研究 Study on wind profile and its reduction effects caused by arrangement condition of ground-mounted photovoltaic panels	
共同研究要旨 Summary of Joint Research	This research aims to investigate the characteristic of wind profile and its reduction effects in the downstream behind the ground-mounted photovoltaics (PV) panels. Wind tunnel tests were carried out using a boundary-layer wind tunnel (width 0.78 m, height 0.5 m, length 7.2 m) installed in the Arid Dome of Arid Land Research Center. The tilted flat plates were set as a 1/100 scale of PV panels and the wind speed profiles up to a height of about 20 m from the ground were simulated as the inflow condition to the panels in the wind tunnel. The roughness length of inflow wind profiles in the modeled scale was also set to about 3.0×10-5 m, assuming to the roughness length of grassland to sand dune. The wind speed profile behind the plates were measured under the condition with the row number of panels (n = 3, 6, 9), the tilt angle (θ = 10°, 20°, 30°) and the wind direction to the plates (front side and rear side). The variation of the wind speed ratio which is defined as the ratio of the wind speed at the distance (x) behind the panels to the inflow wind speed has been discussed. From the results of wind tunnel experiment, it is obtained the wind speed in the range of about 4 times of the tilted panel height (H) is 10-20% reduction from the inflow wind speed in the downstream region behind the panels (x / H = 30 to 60). In addition, it is shown that the reduction effects of these conditions on the inflow wind speed become larger with the increase of the number of panel rows and the tilt angle of the panels.	

一般研究 34 General Research 34	対応教員 Corresponding Staff	木村　玲二 Kimura, Reiji
研究代表者 Principal Researcher	濱　侃（千葉大学大学院園芸学研究院） Hama, Akira (Graduate School of Horticulture, Chiba University)	
研究課題 Research Subject	サツマイモにおける窒素吸収量と生育期間の気象条件の関係についての研究 Studies on the relationship between nitrogen absorption and meteorological conditions of the growing season in sweet potatoes	
共同研究要旨 Summary of Joint Research	In 2022, cultivation experiments and soil analysis were conducted to develop a new model for evaluating soil nutrient condition. The concentration of inorganic nitrogen in the soil is correlate with soil temperature or air temperature. Therefore, the concentration of inorganic nitrogen is expressed as following equations (1, 2). $N = N_0\ [1–\exp(–k\ t)\ ]$ (1) $k = A\ exp((–Ea) / RT)$ (2) where, N is inorganic nitrogen (mgN/100g), N_0 is organic nitrogen before reaction (mgN/100g), t is elapsedtime (day), k is rate constant (day^{-1}), A is pre-exponential factor, Ea is activation energy (cal mol^{-1}), R is universal gas constant (1.987cal deg^{-1} mol^{-1}) and T is absolute temperature (deg). The value of factor A is $4.8×10^{-2}$ in this study. As a simple method, an empirical regression model between the amount of inorganic nitrogen in the soil and the above-ground nitrogen was created, and the amount of inorganic nitrogen in the soil was estimated from the drone-based above-ground nitrogen. Although the number of samples is still small, we were able to show that an RMSE of 1.34 can estimate the amount of nitrogen in the soil. In summary, it is highly possible to estimate the state of nutrients (nitrogen dynamics) in the soil simply by combining the above-ground nitrogen estimation by drones and meteorological data.	

一般研究 35 General Research 35	対応教員 Corresponding Staff	藤巻　晴行 Fujimaki, Haruyuki
研究代表者 Principal Researcher	竹内　真一（東海大学海洋学部） Takeuchi, Shinichi (School of Marine Science & Technology, Tokai University)	
研究課題 Research Subject	傾斜地自己集水型熱帯果樹栽培の試行 Trial of tropical fruit cultivation based on water harvesting on slopes	

共同研究要旨 Summary of Joint Research	A cultivation system without depending on energy to reclaim devastated tea garden have been ex-perimentally examined while is consisted of a water collection sheet on the upper part of the slope to store rainfall in a tank, and planting avocados on the lower part. The catchment area was increased and avocado seedling were transplanted and soil moisture sensor changed to big size, those were altered compared to last year. A water storage tank was added, almost the required amount of irrigation water could be obtained. One Bacon and one Mexicola were planted on April 29th in a 100L pot with an expanded root sysytem. Cultivation tests were conducted by drip irrigation until October 7, with volumetric water contents of 32% and 30% as starting points for irrigation. The density of emitters was increased in order to secure a moist area for irrigation after planting. Sap flow measurement was applied to both trees. Normally, the sap flow rate increases with the lapse of time due to the smooth growth of seedlings, however the sap flow rate tended to decrease, and showed a tendency to repeat a temporary increase only after sufficient rainfall. Based on this measurement fact, a micro-sprinkler that can reproduce the wet condition after rainfall was installed to expand the wet area. After that, the sap flow rate increased and reached a maximum of twice that of drip irrigation. Avocado is characterized by many root groups distributed on the soil surface, and under drip irrigation that forms a localized moist area, there is a relationship between partially dry root groups and stomatal closure, and overall moistness and stomata closure. It is thought that this indicates that under-tree irrigation with low rainfall and micro-sprinklers does not reduce stomatal opening.

一般研究 36 General Research 36		対応教員 Corresponding Staff	石井　孝佳 Ishii, Takayoshi
研究代表者 Principal Researcher	那須田　周平（京都大学大学院農学研究科） Nasuda, Shuhei (Graduate School of Agriculture, Kyoto University)		
研究課題 Research Subject	イネ科植物の染色体工学による新規ゲノム改編システムの開発 Development of a novel system to modify genomes by means of chromosome engineering of Poaceae species		
共同研究要旨 Summary of Joint Research	We have successfully reorganized the wheat genome by utilizing the gametecidal (Gc) genes or chromosomes derived from wheat relatives Aegilops spp., which induce structural aberrations in the genome of bread wheat either in the processes of gametogenesis or early embryonic development. Currently, we are elucidating the causal genes of the Gc action at the molecular level and are searching for candidate sequences for the Gc gene. When crossing pollen with the Gc gene to a strain without having the gene, chromosomal breaks occur in the zygote (Tsujimoto and Tsunewaki 1985; King and Laurie 1993). We have demonstrated that the breakage occurred in the first zygotic cell division (Yamada et al., unpublished). This system can be used to reorganize the genome of the female parent probably not only wheat but other crop species. The intrinsic difficulty of this system is selective transmissibility of the Gc gene; the Gc gene is preferentially transmitted to progeny and causes semi-fertility fertility in progeny due to its ability to cause gametophytic sterility, which is not desired in breeding. Dr. Takayoshi Ishii at Tottori University is leading the studies of wide crosses between Poaceae species. Of them pearl millet (*Pennisetum glaucum* (L.) R.Br) is unique in terms of uniparental chromosome elimination when crossed as pollen parent to wheat female parent. In the early zygotic cell divisions, the pearl millet chromosomes are selectively not included in the nucleus. Thus, the resulted offspring is haploid of the female parent. We have started combining the advanced researches at Kyoto and Tottori Universities to establish a system to induce genome rearrangements in crops without negative effects of the selfish gene. In the given research period of 2022, we have conducted the following researches; (1) We have identified several candidate sequences of the Gc gene and cloned into a vector system with different promotors. We established a reporter constructs with histone H3 gene connected with fluorescent proteins. (2) We started test crosses between pearl millet and wheat.		

一般研究 37 General Research 37		対応教員 Corresponding Staff	黒崎　泰典 Kurosaki, Yasunori
研究代表者 Principal Researcher	長田　和雄（名古屋大学大学院環境学研究科） Osada, Kazuo (Graduate School of Environmental Studies, Nagoya University)		
研究課題 Research Subject	黄砂・PM2.5 など長距離輸送される大気エアロゾルの観測 Observation of long-range transported atmospheric aerosols such as Kosa and PM2.5		

共同研究要旨 Summary of Joint Research	Observation of size-segregated aerosol concentrations at the roof top of the ALRC building has been continued by using PM712 since 2013. In addition, atmospheric aerosol particles were sampled on a PTFE tape filter separately for coarse (PMc: 10 to 2.5 μm in diameter) and fine (PM2.5: less than 2.5 μm) particles. The size-segregated aerosol samples on the PTFE tape filter were analyzed in our Lab at Nagoya University. Data on long-term size-segregated ionic composition are very valuable to study source-receptor relationship of pollutants in the west Pacific region. During the past 8 years, the concentration of ammonium sulfate, the major component of PM2.5, has shown a continuous decreasing trend, while the nitrate concentration does not show clear trend of change. The concentration of ammonium in coarse particles in the spring of 2020 was significantly lower than in the preceding and following years, which might be resulted from lock-down effects of COVID-19 in China. Aerosol samples for electron microscopy were also collected by an automated sampler with the cooperation of the corresponding faculty and his laboratory during March to May 2021. The samples were tested for the reagent thin film method to show the presence of nitrate or ammonium in a particle. The individual particle composition was also investigated by using SEM/EDX analysis for co-existing particles with nitrate and ammonium in coarse particles.

一般研究 38 General Research 38	対応教員 Corresponding Staff	辻本　壽 Tsujimoto, Hisashi
研究代表者 Principal Researcher	花田　耕介（九州工業大学大学院情報工学研究院） Hanada, Kousuke (Graduate School of Computer Science and Systems Engineering, Kyushu Institute of Technology)	
研究課題 Research Subject	多様な植物共生菌による植物の生理活性変化の分子メカニズムの解明 Molecular mechanisms of plant physiological changes caused by various plant symbiotic fungus	
共同研究要旨 Summary of Joint Research	A filamentous fungus Colletotrichum tofieldiae (Ct) has been shown to play a role in supplying phosphorus to Arabidopsis thaliana when it is in a phosphorus-deficient state. To determine the growth-promoting and growth-suppressing effects of Ct on Arabidopsis thaliana, we hypothesized that salicylic acid signaling, a typical plant defense response to pathogen attack, was involved. In this study, we aim to clarify what kind of changes occur in Arabidopsis thaliana and Ct when the symbiotic effect (growth promoting effect) and pathogenic effect (growth suppressing effect) are observed due to changes in phosphorus concentration. rice field. As a result of coexistence of Ct and Arabidopsis thaliana at different phosphorus concentrations (25, 150, 625 μM), it was quantified that Ct showed a growth-promoting effect at low phosphorus concentrations (25 μM) and inhibited growth at high phosphorus concentrations (625 μM). clearly revealed. At this time, phosphorus in the plant increased when Ct coexisted at all phosphorus concentrations, suggesting that Ct supply phosphorus to Arabidopsis thaliana at any phosphorus concentration. Furthermore, it was clarified that the amount of Ct in Arabidopsis thaliana did not change according to the phosphorus concentration. In addition, the transformant (ics1), in which the salicylic acid signal of the plant defense response does not move, was inhibited in growth at both low and high phosphorus concentrations by coexistence with Ct. The growth-promoting effect at concentration was lost. This result suggests that plant defense responses play an important role in the growth-promoting effect of Ct on Arabidopsis thaliana. Furthermore, we measured the amount of Ct in the ics1 mutant, and found that the amount of Ct increased significantly compared to that of the Col-0 strain, indicating that the protective response by salicylic acid signals contributes to the suppression of the amount of Ct infected. Therefore, in order to quantify the activity of salicylic acid in plants, we compared the expression levels of PR1, a marker gene for salicylic acid signals, and found that salicylic acid signals were enhanced at low phosphorus concentrations com-pared to high phosphorus concentrations. . These results suggest that the growth-promoting effect of Ct on Arabidopsis thaliana at low phosphorus concentrations is related to the activation of defense re-sponses by salicylic acid signals. Next, we compared the expression levels of genes that adversely affect plant growth in order to observe whether the Ct caused functional changes in Arabidopsis thaliana by changing the phosphorus concentration. It was not adjusted, suggesting that Ct did not change their aggressiveness depending on the phosphorus concentration. These results suggest that Arabidopsis thaliana maintains a symbiotic relationship by sensing changes in phosphorus concentration and Ct, and enhancing its defense against Ct.	

一般研究 39 General Research 39		対応教員 Corresponding Staff	山中　典和 Yamanaka, Norikazu
研究代表者 Principal Researcher	松尾　奈緒子（三重大学大学院生物資源学研究科） Matsuo, Naoko (Graduate School of Bioresources, Mie University)		
研究課題 Research Subject	安定同位体比を用いたアラル海およびカスピ海地域に生育する塩生植物の水利用特性の評価 Evaluation of water use of halophytes in the Aral and Caspian Sea regions using stable isotope ratios		
共同研究要旨 Summary of Joint Research	In order to predict the response of dryland ecosystems between the Aral and Caspian Seas in Central Asia to climate change, it is necessary to understand the relationship between water use characteristics of halophytes and environmental conditions in their habitats. The stable carbon isotope ratio ($\delta^{13}C$) of leaf organic matter is used to distinguish photosynthesis types (C3, C4, and C3-C4 intermediate) and to evaluate intrinsic water use efficiency (= photosynthetic rate/ stomatal conductance) in C3 plants. On the other hand, the stable oxygen isotope ratio ($\delta^{18}O$) of leaf organic matter is known to reflect transpiration rate and $\delta^{18}O$ of water absorption sources, regardless of photosynthesis type, and is expected to be used to evaluate transpiration characteristics of halophytes. However, information on $\delta^{18}O$ of halophytes in dryland ecosystems is still lacking. Since field surveys in the Caspian Sea, Russia, were not possible in both 2021 and 2022, the $\delta^{13}C$ and $\delta^{18}O$ of dry samples of photosynthetic organs were measured for 57 species of halophytes collected at three sites in Uzbekistan. The effects of environmental factors such as annual precipitation and annual mean temperature and eco-physiological factors such as photosynthesis type (C3, C4), life form (annual herb, perennial herb, woody), and root depth (shallow rooted ~3m, deep rooted 3m~) on the $\delta^{18}O$ of photosynthetic organs were examined using multiple regression analysis. The $\delta^{18}O$ of photosynthetic organs was significantly affected by photosynthesis type, life form, root depth, and annual precipitation. It is found that the $\delta^{18}O$ of photosynthetic organs was lower with higher annual precipitation and higher in shal-low-rooted plants than in deep-rooted plants. It is reported that $\delta^{18}O$ of rainwater is negatively correlated with the amount of precipitation and that $\delta^{18}O$ of shallow soil water is higher than that of deep soil water due to evaporation from soil surface. These results suggest that the $\delta^{18}O$ of photosynthetic organs of halophytes in this region may reflect the $\delta^{18}O$ of water absorbed by those plants. It is also found that the $\delta^{18}O$ of photosynthetic organs of C3 -type halophytes was higher in shallow-rooted plants than in deep-rooted plants, higher in arid conditions with less precipitation and higher temperature, and higher with higher intrinsic water use efficiency. These results suggest that $\delta^{13}C$ and $\delta^{18}O$ of dry samples can be used to evaluate the water use characteristics of C3-type halophytes in dryland ecosystems in Uzbekistan, and the $\delta^{18}O$ of water absorption source should be taken into account when doing so.		

一般研究 40 General Research 40		対応教員 Corresponding Staff	藤巻　晴行 Fujimaki, Haruyuki
研究代表者 Principal Researcher	斎藤　広隆（東京農工大学大学院農学研究院） Saito, Hirotaka (Institute of Agriculture, Tokyo University of Agriculture and Technology)		
研究課題 Research Subject	地表面付近の空気の乱れが土中と大気の物質・熱の交換に与える影響 Effects of air turbulence near the ground surface on water and heat exchange between the soil and atmosphere		
共同研究要旨 Summary of Joint Research	Evaporation from the soil surface is determined by the potential evaporation rate determined by boundary environmental conditions such as wind speed, temperature, humidity, and the soil wetness. In this study, a wind tunnel was first constructed to control the air flow and to control the potential evaporation rate and air turbulence. A schematic diagram of the wind tunnel is shown in the figure above. The air intake section (far left in the figure) has a large panel with an aluminum honeycomb structure, while the air exhaust section (far right in the figure) has a similar honeycomb panel. An acrylic soil column with an open top surface, placed on an electronic balance, was placed in the air flowing area near the center to enable evaporation experiments under various wind velocity conditions. The air velocity was controlled by varying the input voltage to a blower installed in the exhaust section. A Marriott water tank was connected to the acrylic soil tank to control the groundwater level. Evaporation experiments were conducted with different soil types and wind speeds to clarify the effect of different wind speeds, or potential evaporation rates, on evaporation from the surface. In addition, evaporation experiments were conducted by changing the soil properties of top 2 cm of the surface layer in order to clarify the effect of the layering on soil water evaporation.		

	The results showed that different soil types, with or without layering, had different evaporation suppression effects. In particular, when coarse-grained soil was placed on top of fine-grained soil (silt), the evaporation suppression effect was greatly enhanced, and under conditions with a high potential evaporation rate, the accumulated evaporation was suppressed to about one-third that of a single-layer soil. In the future, we will investigate the effect of air flow turbulence on soil water evaporation.

一般研究 41 General Research 41		対応教員 Corresponding Staff	山中　典和 Yamanaka, Norikazu
研究代表者 Principal Researcher	大手　信人（京都大学大学院情報学研究科） Ohte, Nobuhito (Graduate School of Informatics, Kyoto University)		
研究課題 Research Subject	インド西部の乾燥地マングローブ林バイオマスの長期変動の把握 Long-term biomass estimation of mangroves in the arid region of western India		
共同研究要旨 Summary of Joint Research	(1) Long-term variation in mangrove forest biomass Using Landsat 5, 7, and 8 images with medium spatial resolution, NDVI was calculated as an indicator of biomass for the communities identified based on residents' narratives, and long-term and seasonal variations in biomass from the 1988 to 2021 were observed. The results showed that biomass tended to increase in many communities over the long term. (2) Analysis of the effects of climate change The results of this analysis were discussed with long-term data on rainfall in the area, and a period of slowdown in the increase of NDVI was detected during a series of low rainfall years from the late 1990s to the early 2000s, indicating that intense drought had suppressed the growth of canopy biomass. (3) Evaluation of the impact of development and other factors on long-term changes in mangrove forest biomass The spatial distribution of mangrove forest loss and extension were clarified. The results showed that although some areas were lost due to erosion by ocean currents, these areas accounted for less than a few percent of the total area. On the other hand, areas of increased coverage were also detected, albeit to a lesser extent. Loss due to human causes such as logging was observed in certain areas, such as areas where salt pans had been developed, but for the most part there was no loss that could be considered to be human induced, indicating that local residents were using the mangroves while preserving it. (4) Impacts of cattle ranching in mangrove forests From the residents' narratives, it is known that access to mangrove forests by pastoralists has been restricted by the local government forestry department since 2005. This measure was intended to prevent the decline of mangroves due to camel grazing by pastoralists. However, the above-mentioned observation of long-term changes showed that the trend before 2005 also showed a monotonous increasing, indicating that traditional grazing did not have a negative impact on the growth of mangroves.		

一般研究 42 General Research 42		対応教員 Corresponding Staff	坪　充 Tsubo, Mitsuru
研究代表者 Principal Researcher	松永　忠雄（鳥取大学工学部） Matsunaga, Tadao (Faculty of Engineer, Tottori University)		
研究課題 Research Subject	植物栽培のための超小型受光センサを用いた多点同時光環境計測の定量評価の研究 Studies on quantitative evaluation of multi-point optical spectrum measurement system using ultra-small optical sensors for plant cultivation		
共同研究要旨 Summary of Joint Research	In this study, we propose an optical fiber multipoint light measurement system to investigate quantitatively a proper light environment for plant cultivation. For better quality and faster cultivation, various vinyl films have been researched and commercialized to control the light environment inside the greenhouse. Those functional vinyl films are evaluated only subjectively by the plant cultivation results. Here, to evaluate the influence of functional vinyl film for greenhouse quantitatively, we investigate the light environment around a plant individual using the proposed light measurement system. The optical fiber multipoint light measurement system was designed to suitable for a real time and long-term measurement. To detect light environment around a plant individual, we utilized an optical fiber. The light is received by about 0.1 mm diameter optical fibers. Finally, the received light is analyzed by spectrometer. With the measurement system, we investigated the light environment in the greenhouse. As a result, we found that near plant roots the intensity of infrared region becomes strong that was not absorbed into the leaf.		

一般研究 43 General Research 43		対応教員 Corresponding Staff	黒崎　泰典 Kurosaki, Yasunori
研究代表者 Principal Researcher	中野　智子（中央大学経済学部） Nakano, Tomoko (Faculty of Economics, Chuo University)		
研究課題 Research Subject	画像データを用いた草原生態系の植生動態解析 Estimation of vegetation dynamics in semiarid grasslands by using image data		
共同研究要旨 Summary of Joint Research	Greenness indices derived from near-surface photography have been increasingly used for the continuous and automated monitoring of vegetation for various ecosystems. The purpose of the present study is to examine characteristics and applicability of green chromatic coordinate (GCC) for monitoring vegetation dynamics in semi-arid grasslands. Digital images had been collected using time-lapse cameras at intervals of 10 minutes at two grassland sites in Mongolia from 2016 to 2019. The GCC was calculated from the digital number values of red, green, and blue channels of the images. The results demonstrated that (i) GCC values on sunny days were almost constant between 11:00 LT and 15:00 LT regardless of solar altitude and direction. However, the GCC showed erroneous values under low illumination conditions on cloudy and rainy days. (ii) The GCC showed clear seasonal changes similar to the satellite-based NDVI and greenery ratio (GR). The variation in GCC agreed better with that in GR than NDVI. (iii) The value of GCC was highly correlated with plant aboveground biomass, gross primary production, and ecosystem respiration. Thus our results suggest the feasibility of using a digital camera system for continuous long-term monitoring of vegetation dynamics and phenology in semi-arid grasslands.		

⑶ 若手奨励研究 / Incentive Research by Young Scientists

若手奨励研究 1 Incentive Research by Young Scientists 1		対応教員 Corresponding Staff	黒崎　泰典 Kurosaki, Yasunori
研究代表者 Principal Researcher	江 嘉敏（理化学研究所計算科学研究センター） Kong, Kaman (R-CCS, RIKEN)		
研究課題 Research Subject	21 世紀の乾燥地における気候変動と人間活動影響下の持続可能な生態系構築 Establishing a sustainable drylands ecosystem under climate change and human activities in the 21st century		
共同研究要旨 Summary of Joint Research	Due to the complexity of climate change and human activities, their impacts on dryland people and ecosystems are still uncertain. In this study, we focus on Mongolian grasslands and aim to understand the interactions between the dryland environment and human-climate in the future. In 2022 FY, two CMIP5 model outputs (HadGem2 and Echam5) under RCP4.5 and RCP8.5 scenarios were downscaled with bias-correction methods by Dr. Gomboluudev Purevjav over the Mongolian area. In the preliminary step, we selected two target sites in Mongolian grasslands, Tsogt-Ovoo (TsO, located in the Desert Steppe area, 44.42N 105.32E) and Bayan-Unjuul (BU, located in the Steppe area, 46.85N 105.95E), and simulated their 100-year environment using an ecosystem model (DAYCENT) under RCP 4.5 and 8.5 scenarios of HadGem2 output. Compared with the simulated aboveground biomass (AGB) under these two scenarios (Fig. 1), the number of years with low vegetation under RCP8.5 is more than that under RCP4.5 since 2040 at TsO. At BU, a sudden drop under RCP8.5 after 2060 implies the extreme weather may limit plant production due to other environmental constraints. These results show large spatial and temporal variations in AGB among Mongolian grasslands. At the end of this FY, we received the observation of AGB and are now going to validate these simulation results. Moreover, to identify the differences in the climate variables (temperature and precipitation) under the historical period (1990–2015) between CMIP5 models and ob-servation, the CRU TS (Climatic Research Unit gridded Time Series, Harris et al., 2020) dataset is going to be used.		

若手奨励研究 2 Incentive Research by Young Scientists 2		対応教員 Corresponding Staff	石井　孝佳 Ishii, Takayoshi
研究代表者 Principal Researcher	濱本　亨（東北大学大学院農学研究科） Hamamoto, Toru (Graduate school of Agricultural Science, Tohoku University)		

研究課題 Research Subject	作物の遺伝的多様性が支配する土壌微生物生態系とその機能 Soil microbial ecosystems and their functions dominated by crop genetics
共同研究要旨 Summary of Joint Research	Tropical soils are often oligotrophic and vulnerable to agricultural production due to future climate change (Lal et al., 2019, Soil Till. Res.). Underutilized crops, which can grow in poor environments, such as cowpea, and their genetic diversity are the focus of significant attention and understanding (e.g., Rhonée et al., 2020, Nat. Commun.). Above-ground diversity plays a key role in below-ground diversity (i.e., soil microbes) and associated biogeochemical cycles. Many legumes form symbiotic associations with specific bacteria and form rhizobia in their roots to fix nitrogen. On the other hand, there is still no unified view on how soil type and genotype influence rhizosphere (Amorim et al., 2022, Appl. Soil Ecol.; Leite et al., 2017, Front. Plant Sci.). Therefore, the nitrogen self-sufficiency capacity of each genotype can be assessed by examining the potential of nodule-forming capacity and the rhizosphere microbial community structure in an environment with extremely low soil microbial diversity (sandy soil). In FY2022, about 400 different cowpea genotypes from Asia and Africa were sown and grown on the ALRC filed. During the flowering season, we dug up the roots of about 100 cowpea lines, mainly from Japan, out of the 400 cultivated lines. After root nodule sampling and washing, the number and weight of root nodules on each plant was recorded. DNA was then extracted from the nodules using an extraction kit.

若手奨励研究 3 Incentive Research by Young Scientists 3	対応教員 Corresponding Staff	石井　孝佳 Ishii, Takayoshi
研究代表者 Principal Researcher	宇部　尚樹（富山県立大学工学部） Ube, Naoki (Faculty of Engineering, Toyama Prefectural University)	
研究課題 Research Subject	パンコムギにおける乾燥ストレス誘導性二次代謝産物の探索と機能解明 Identification and characterization of drought induced secondary metabolites in wheat	
共同研究要旨 Summary of Joint Research	Drought stress is one of major factors for decreasing crop production because drought stress caused decrease of leaf water relations, membrane stability, and photosynthetic activity, leading to oxidative stress such as accumulation of reactive oxygen species generation in plants. For tolerance against drought stress, plants employ various defense mechanisms to drought stress, including accumulation of secondary metabolites. Drought-induced secondary metabolites contributed to drought stress tolerance in several plants, while the mechanism of drought stress tolerance via secondary metabolites remain to be elucidated. In this study, we aimed to identify drought-induced secondary metabolites and to elucidate the function of the metabolites in bread wheat that one of the most important staple-food crops. Changes in secondary metabolites were analyzed in wheat aerial parts treated drought stress. HPLC analysis detected the accumulation of three compounds in drought-treated aerial parts. Of these, we purified two compounds by silica gel column chromatography and preparative HPLC, and identified them as phenylglycerol esters, 1-*O*-couamroyl-3-*O*-feruloylglycerol and 1,3-*O*-diferuloylglycerol, by spectrometry. To confirm the structures of these phenylglycerols, 1-*O*-couamroyl-3-*O*-feruloylglycerol and 1,3-*O*-diferuloylglycerol were synthesized from glycerol and corresponding hydroxycinnamic acids and NMR spectra of the synthetic compounds were identical with those of phenylglycerols purified from wheat plants. The remaining compound was determined to be tryptophan by mass spectrometry.	

若手奨励研究 4 Incentive Research by Young Scientists 4	対応教員 Corresponding Staff	谷口　武士 Taniguchi, Takeshi
研究代表者 Principal Researcher	赤路　康朗（国立環境研究所生物多様性領域） Akaji, Yasuaki (Biodiversity Division, National Institute for Environmental Studies)	
研究課題 Research Subject	塩ストレス下におけるアーバスキュラー菌根菌定着阻害機構の解明 Mechanism of inhibited colonization of arbuscular mycorrhizal fungi under salinity stress	
共同研究要旨 Summary of Joint Research	At first, we constructed the new cultivation system to test the effect of saltwater immersion on the mycorrhizal formation in plant roots. This cultivation system enables to automatically submerge pots twice a day, which is similar with natural tidal rhythms in mangrove forests. We then sampled mangrove soil including arbuscular mycorrhizal fungi and propagules of *Bruguiera gymnorhiza* and *Rhizophora stylosa* (both are Rhizophoraceae mangroves) in a mangrove forest in Iriomote Island. Using the renewed cultivation systems and sampled soil, we cultivated the two mangrove species for about five months. The total number of pots was 96; two plant species × three salinity levels (0M NaCl, 0.15M	

	NaCl, 0.3M NaCl) × two soil types (seaside and landside soil) × eight replications. After five months, we sampled all 96 mangrove plants, measured electrical conductivity (EC) and pH of soil pore water, stained root-associated fungi using trypan blue solution, and stored plant roots at ¬–80°C for RNA analysis, and we are now conducting the analysis. In addition, based on the results reported last year, we are preparing the draft in which we suggest that salinity stress strongly inhibited mycorrhizal formation in *B. gymnorhiza* roots, whereas mycorrhizal formation in *R. stylosa* was not found even without salinity stress.

若手奨励研究 5 Incentive Research by Young Scientists 5		対応教員 Corresponding Staff	辻本　壽 Tsujimoto, Hisashi
研究代表者 Principal Researcher	妻鹿 良亮（山口大学大学院創成科学研究科） Mega, Ryosuke (Graduate School of Sciences and Technology for Innovation, Yamaguchi University)		
研究課題 Research Subject	サブサハラ地域の過酷な乾燥環境にも対応し得る「節水型耐乾性コムギ」の研究 Research of water-saving drought tolerant wheat that is able to adapt to Sub-Saharan region		
共同研究要旨 Summary of Joint Research	Screening from the TILLING population From the population of wheat lines (TILLING, Targeting Induced Local Lesions in Genome) introduced with point mutations by chemical mutagen, lines containing mutations in the abscisic acid (ABA) receptor gene were used to find water-saving drought-tolerant lines. Mutations in the ABA receptor gene tune the sensitivity to ABA and affect the elongation of seedlings. Therefore, we compared the elongation of seedlings in the ABA-treated and non-treated groups and selected lines with a strong effect of suppressing elongation. Cultivation of experimental genotypes for trait evaluation in the field Cultivation of a set of recombinant inbred line (RIL) populations (F7 generation, 221 lines) obtained by generation promotion was started at the end of November 2022 in the rainout shelter field of the Arid Land Research Center. In 2023, when the plants have grown sufficiently, we plan to measure the photosynthetic rate and transpiration rate, and sample the metabolome analysis. At the same time, non-destructive data acquisition is performed using multispectral cameras and drones. In addition, during the grain-filling period in June, we plan to harvest the seeds of each line and collect flag leaf samples for carbon isotope ratio measurement. The obtained trait data will be analyzed and the drought tolerance of the RIL line will be evaluated. Carbon isotope ratio analysis of RIL strains We analyzed the carbon isotope ratio of the F6 accession population of RIL cultivated at the Arid Land Research Center last year, and evaluated the distribution of the carbon isotope ratio values using a histogram (Fig. 2). This indicates that the F6 population of RIL maintains a variety of carbon isotope discrimination, suggesting varied water-saving drought-tolerant traits.		

若手奨励研究 6 Incentive Research by Young Scientists 6		対応教員 Corresponding Staff	黒崎　泰典 Kurosaki, Yasunori
研究代表者 Principal Researcher	河合 慶（名古屋大学大学院環境学研究科） Kawai, Kei (Graduate School of Environmental Studies, Nagoya University)		
研究課題 Research Subject	ゴビ砂漠におけるダスト観測ネットワークの展開と利用 Development and application of dust observation network in the Gobi Desert		
共同研究要旨 Summary of Joint Research	Because of the global spread of COVID-19, this research project was unable to conduct research activities in FY2021, and the research period was extended to FY2022. The research results of FY2022 are shown below. We planned to visit Mongolia in April-May 2021 and install the compact dust sensors which we had developed under our previous joint research project at multiple locations in the Gobi Desert, but this plan was cancelled due to the COVID-19 pandemic. After that, we were finally able to visit Mongolia in September 2022 and repaired the ceilometers installed at Dalanzadgad and Mandalgobi. These observation instruments are included in the Gobi Desert Dust Observation Network, which is developed and used in this joint research project. The ceilometer installed at Mandalgobi had been broken due to a lightning strike just before the COVID-19 pandemic, but this time we successfully repaired it while communicating remotely with the manufacturer, Lufft (Germany). We also collected and analyzed the		

	data of the test observation for the compact dust sensor which was conducted at the ALRC Tsogt-Ovoo observation site under our previous joint research project. In addition, using our past observation data, we investigated a method to estimate dust mass concentrations from optical observation data of the ceilometers. The ceilometers can continuously observe vertical distributions of atmospheric dust, but the output data are extinction coefficients, which are mainly determined from the size distributions and number concentrations of dust. In order to convert this parameter to dust mass concentrations, which are easily used in atmospheric environmental research and numerical predictions, we obtained a mass-extinction coefficient factor (MECF) by using our simultaneous observation results of the ceilometer and a tethered balloon at Dalanzadgad. We are writing a paper about this result now. The principal investigator of this research project (Kawai) was awarded the Yamamoto Award of the Meteorological Society of Japan in recognition of his research achievements including those of our joint research projects.

(4) 特定研究 / Specific Research

特定研究 1 Specific Research 1		対応教員 Corresponding Staff	寺本　宗正 Teramoto, Munemasa
研究代表者 Principal Researcher	梁 乃申（国立環境研究所地球システム領域） Naishen Liang (Earth System Division, National Institute for Environmental Studies)		
研究課題 Research Subject	アジア地域を中心とした土壌呼吸および CO_2 交換量に対する乾燥ストレスの影響に関する研究 Influence of drought stress on soil respiration and CO_2 exchange in Asian region		
共同研究要旨 Summary of Joint Research	We conducted water addition treatment and measured soil respiration (Rs) in three grassland ecosystems in Hustai, Mandalgovi, and Bulgan in Mongolia in late August 2022. There was no significant change in Rs due to water addition compared with control (no water addition) in Hustai and Mandalgovi. On the other hand, water addition treatment significantly increased Rs in Bulgan. This result suggested that Rs in the grassland ecosystem in Bulgan was suppressed under drought stress in late August 2022. In Tottori dunes, we continued measurement for CO_2 fluxes from April to June in coastal plant communities. There were exponentially significant relationships between soil temperature (Ts) and Rs in all coastal vegetation communities from 2021 to 2022. On the other hand, relationships between volumetric soil moisture (SM) and Rs were weaker compared with Ts because of the large precipitation in August 2021 and the resultant small seasonal variation of SM. In addition, based on Rs data in 2020, we found the response of Rs to summer drought was varied in plots of different vegetation environ-ments in Tottori dunes. In Higashi-Hiroshima and Tsukuba, significant exponential relationships between Ts and Rs were confirmed as of 2021. In Higashi-Hiroshima, missing data in the summer of 2022 due to mechanical trouble made it difficult to analyze the influence of drought on Rs in 2022. In Tsukuba, different from 2021, SM decreased in summer and the significant relationship between SM and Rs was confirmed. In Hebei and Malaysia, we could not get good-quality continuous measurement data from 2021 to 2022 due to COVID-19. Therefore, we analyzed continuous measurement data in 2019 in Heibei and Rs data by the portable system from 2011 to 2020 in 4 sites in Malaysia. In Hebei, SM was kept low level in the summer of 2019, but Ts was dominant on the seasonal variation of Rs and the influence of drought stress was limited. In Malaysia, it was suggested that the influence of El Nino on Rs (drought stress and the resultant decrease of Rs) might be continued until 2017 in the primary forest site even though El Nino was finished in the spring of 2016.		

(5) 重点研究 / Focused Research

重点研究 1 Focused Research 1		対応教員 Corresponding Staff	恒川　篤史 Tsunekawa, Atsushi
研究代表者 Principal Researcher	大黒　俊哉（東京大学大学院農学生命科学研究科） Okuro, Toshiya (Graduate School of Agricultural and Life Sciences, The University of Tokyo)		

研究課題 Research Subject	エチオピア北部高地における管理体制の異なる放牧草地での生物多様性と生態系機能の関係解明に関する研究 Studies on the relationship between biodiversity and ecosystem functioning under different grazing management regimes in the highlands of Northern Ethiopia.
共同研究要旨 Summary of Joint Research	Due to travel restrictions, field surveys could not be conducted as planned, so data analysis on the functional traits of the plant species was carried out using preliminary survey data to attempt to assess functional diversity. Basic information on functional traits, including leaf dry matter content (LDMC), specific leaf area (SLA), and leaf nitrogen and phosphorus content, was collected for 19 main plant species from three sites each in year-round grazing (free grazing) and seasonal grazing areas. Then Community Weighted Mean (CWM) for each trait was calculated The results showed that SLA was significantly higher in seasonal grazing areas ($p<0.05$), while leaf nitrogen content was significantly higher in free grazing areas ($p<0.05$). However, there were no significant differences in LDMC and phosphorus content CWMs. These findings suggest that the impact of grazing management on vegetation functional diversity may vary depending on the type of functional trait studied. Furthermore, since travel to the site became possible in the latter half of the year, investigations on ecosystem function were initiated. To evaluate organic matter decomposition and nutrient cycling functions, standard samples were installed. In March 2023, during the mid-dry season, 5 sites were selected within the Gudar settlement in the Amhara region of Ethiopia for each of the following: free grazing areas, seasonal grazing areas, and tree-planted areas (Acacia diccurens plantation, 3 years old). Tea bags (Lipton green tea (EAN:87 22700 05552 5) and Lipton rooibos tea (EAN:87 22700 18843 8)) were buried at 6 locations within each site. As a next step, tea bags buried will be retrieved during the early and late rainy seasons, and organic matter decomposition ability will be evaluated using the Tea Bag Index (Keuslamp et al., 2013: Methods in Ecology and Evolution). Additionally, measurements of aboveground and belowground biomass and nutrient content will be taken during the late rainy season to further evaluate ecosystem function.

1.4 国内外との交流 / Exchange Programs

（1）学術交流協定 / Agreements of Academic Exchange and Cooperation

As of March 31, 2023

国名等 Country/Region	機関名	Names of Institutions
中国 China	北京林業大学	Beijing Forestry University
	新疆農業大学	Xinjiang Agricultural University
	蘭州大学	Lanzhou University
	中国科学院水利部水土保持研究所	Institute of Soil and Water Conservation, CAS and MWR
	中国科学院遺伝及び発育生物学研究所農業資源研究センター	Center for Agricultural Resources Research, Institute of Genetics and Developmental Biology, CAS
	中国科学院西北生態環境資源研究院	Northwest Institute of Eco-Environment and Resources, (NIEER), CAS
モンゴル Mongolia	気象水文環境情報研究所	Information and Research Institute of Meteorology, Hydrology and Environment
	モンゴル科学アカデミー地理学・地生態学研究所	Institute of Geography and Geoecology, Mongolian Academy of Sciences
レバノン Lebanon	国際乾燥地農業研究センター	The International Center for Agricultural Research in the Dry Areas (ICARDA)
イスラエル Israel	エルサレム・ヘブライ大学ロバートH. スミス農業食料環境学部	The Robert H. Smith Faculty of Agriculture, Food and Environment, the Hebrew University of Jerusalem
スーダン Sudan	スーダン農業研究機構	Agricultural Research Corporation
	ハルツーム大学	University of Khartoum
チュニジア Tunisia	乾燥地域研究所	Arid Regions Institute
エチオピア Ethiopia	バハルダール大学	Bahir Dar University
メキシコ Mexico	国立農牧林業研究所	National Institute of Forestry, Agricultural and Animal Research (INIFAP)
イタリア Italy	バーリ地中海農学研究所	he Mediterranean Agronomic Institute of Bari (CIHEAM-Bari)
オーストラリア Australia	西オーストラリア大学	The University of Western Australia
アラブ首長国連邦 UAE	国際塩生農業研究センター	International Center for Biosaline Agriculture (ICBA)
ウズベキスタン共和国 The Republic of Uzbekistan	サマルカンド国立大学	Samarkand State University

(2) 国際共同研究 International Joint Research

砂漠化対処に向けた次世代型「持続可能な土地管理（SLM）」フレームワークの開発

期間：2017 年 4 月－ 2023 年 3 月
代表者：恒川篤史
組織：鳥取大学（恒川篤史、藤巻晴行、Nigussie Haregeweyn AYEHU、谷口武士、小林　伸行他）、島根大学（増永二之他）、東京大学（大黒俊哉他）、バハルダール大学（Enyew Adgo，Derege Meshesha 他）
研究費：地球規模課題対応国際科学技術協力プログラム（SATREPS）
課題：エチオピアを対象に、土壌侵食防止機能の強化、土地生産力の向上、住民の所得向上を組み込んだ次世代型持続可能な土地管理のフレームワークを提案する。降雨による土壌侵食の激しい青ナイル川上流域の 3 地域（高地、中間地、低地）に設置する研究サイトにおいて、土壌侵食の削減や耕畜連携システムの導入により土地生産力を向上する技術を開発し、さらにそれを住民の生計向上につなげる手法を開発する。土壌侵食の削減、土地生産力の向上、住民の生計向上に貢献。「持続可能な土地管理」は、すでに砂漠化対処に向けて世界的に広く実施されているが、その効果や持続性の問題が指摘されている。本プロジェクトでは、開発された個別要素技術とそれらが普及していくための取り組み・手法を定式化し、青ナイル川流域および世界の乾燥地への展開を目指す。

アフリカの多様な環境における農業気候リスク管理のためのレジリエントｅファーミングの開発

期間： 2021 年 4 月－ 2024 年 3 月
代表者：坪充（鳥取大学乾燥地研究センター）
組織：鳥取大学乾燥地研究センター（坪充）・南アフリカ農業研究機構（モヘレ・モレチィ）・セネガル農業研究所（グヴルベルト・ドレゴ）
研究費：国立研究開発法人科学技術振興機構
課題：本プロジェクトは、気候予測を利用して、意思決定支援システムを開発することにより、サブサハラアフリカの農業干ばつリスク管理における科学技術の発展を目的とする。現在気候と将来気候の季節性に対する作物応答を理解するために、日本、南アフリカ、セネガルが参加する学際的な研究を行っている。特に、日本チームは作物モデルの開発・検証を行い、アフリカチームは気候データ解析、気候予測、収量調査・圃場試験、農家脆弱性評価および気候変動影響評価を行っている。

環境再生型農業技術の導入による地域経済振興のための農業農村開発に関する分野横断的課題分析研究

期間： 2022 年 4 月－ 2024 年 3 月
代表者：坂智広（横浜市立大学木原生物学研究所）
組織：鳥取大学乾燥地研究センター（飯田次郎）、タジキ

(2) International Joint Research

Development of Next-Generation Sustainable Land Management (SLM) Framework to Combat Desertification

Period: Apr. 2017- Mar. 2023
Leader: A. Tsunekawa, Tottori University
Organization: Tottori University (A. Tsunekawa, H. Fujimaki, Nigussie Haregeweyn AYEHU, T. Taniguchi, N. Kobayashi and others), Shimane University (T. Masunaga and others), University of Tokyo (T. Okuro and others) Bahir Dar University (Enyew Adgo, Derege Meshesha and others) Funding: Science and Technology Research Partnership for Sustainable Development (SATREPS)
Subject: Proposing a framework for next-generation sustainable land management (SLM)
The project will propose a framework for next-generation SLM in Ethiopia, incorporating effects such as enhanced prevention of soil erosion, improvement of land productivity and increasing local residents' income. Research sites will be set up in three different areas (highland, midland and lowland) in the Upper Blue Nile Basin, which suffers from serious soil erosion caused by rainfall so as to develop practices and technologies for improving land productivity by reducing soil erosion and introducing crop-livestock production systems as well as linking such efforts to improving the livelihoods of local residents. Contribution to reduction of soil erosion, improvement of land productivity and local residents' livelihoods
Various SLM practices targeted to fight desertification have been implemented in many areas of the world, but their sustainability and effectiveness are being questioned. Hence this project aims to develop improved SLM technologies and approach that could address the major limitations of the currently implemented SLM practices and then to propose them to be used in the study sites and beyond such as to the entire Blue Nile Basin and other arid regions of the world that are experiencing similar problems.

Development of Resilient E-farming for agro-climate risk management in African Multi-environments

Period: Apr. 2021 - Mar. 2024
Leader: M. Tsubo (ALRC, Tottori University)
Organization: Tottori University (M. Tsubo), Agricultural Research Council, South Africa (M. Moeletsi), Senegalese Institute for Agricultural Research (G. Dorego)
Funding: JST
Subject: This project aims to advance science and technology in agricultural drought risk management in sub-Saharan Africa by developing a decision support system that uses climate forecasts. An interdisciplinary study involving Japan, South Africa, and Senegal has been conducted to understand crop responses to the seasonality of current and future climates. Specifically, the Japanese team has developed and validated a crop model, while the African team has conducted climate data analysis, climate forecasts, yield surveys and field trials, and farmer's vulnerability assessment and climate change impact assessment.

Multidisciplinary analysis on the development of agriculture and rural area by introducing regenerative farming techniques for the purpose of regional economic promotion

Period: Apr. 2022 - Mar. 2024
Leader: T. Ban (Kihara Institute for Biological Research,

スタン共和国科学アカデミー・植物学植物生理学遺伝学研究所（フィルザ・ナシーロヴァ）
研究費：鳥取大学、タジキスタン科学アカデミー
課題：タジキスタン政府が国家開発戦略の中で重点政策の 1 つに位置付ける環境再生型農業を導入するに際して、そのタジキスタンでの普及を促進するためには、タジク人の国民性、心性、価値観、歴史や国情、文化、風土などを考慮した、分野横断的なアプローチが有効である、という課題を設定して考察している。この分析を元にして、タジキスタンでの環境再生型農業実施に向けた指針を作成する。

Yokohama City University)
Organization: Arid Land Research Center, Tottori University (J. Iida), Head of Laboratory of Biosafety, Institute of Botany, Plant Physiology and Genetics, Tajik National Academy of Science (TNAS) (F. Nasyrova)
Funding: Tottori University, Tajik National Academy of Science
Subject: The Government of Tajikistan puts a higher priority on the promotion of regenerative agriculture in the National Development Strategy. Following the strategy, in order to extend the regenerative agriculture in Tajikistan, we set up the issue that it is effective to take a multisectoral approach, considering the mentality and the value system of Tajik people, its history, political and socio-economic situation, culture, climate, etc. In this manner the effective guideline of extending regenerative agriculture in Tajikistan will be formulated.

ダストの視点から見た地球人間圏：ダストモデル精度向上のための広域枯れ草量推定
期間： 2022 年 4 月－ 2025 年 3 月
代表者：黒崎泰典（鳥取大学乾燥地研究センター）
組織：鳥取大学乾燥地研究センター（黒崎泰典）・モンゴル気象水文環境情報研究所（B. Gantsetseg, B. Buyantogtokh）・気象研究所（関山剛）・香川大学（石塚正秀）・東京大学（大黒俊哉）
研究費：科研費基盤 B（22H01310）
課題：ダスト（黄砂）は発生域では砂塵嵐という自然災害であり、日本等の風下域においても健康被害をもたらす。しかしながら、砂塵嵐の発生や黄砂飛来を予測するためのダスト数値モデルの精度は十分でない。精度向上できない原因のひとつとして、ゴビ砂漠スケールの広域を対象とした枯れ草量の信頼できる推定ができていないことを挙げられるが、近年、衛星観測で得られる Soil Tillage Index（STI）によって、枯れ草の定量的推定の可能性が見えてきた。本研究では、ゴビ砂漠における枯れ草量測定を行い、この測定データを用いた STI による枯れ草量推定法を確立することで、ダスト発生モデルの精度向上を実現する。

The geo-anthrosphere from a perspective of dust: broad-area estimation of dead vegetation amount to improve the accuracy of numerical dust model
Period: Apr. 2022 - Mar. 2022
Leader: Y. Kurosaki (ALRC, Tottori University)
Organization: Tottori University (Y. Kurosaki), Information and Research Institute of Meteorology, Hydrology and Environment, Mongolia (B. Gantsetseg, B. Buyantogtokh, Meteorological Research Institute (T.T. Sekiyama), Kagawa University (M. Ishizuka), the University of Tokyo (T. Okuro)
Funding: KAKENHI Kiban(B) (22H01310)
Subject: Dust is a natural hazard called a sand & dust storm (SDS) in the emission regions. Even in downwind regions including Japan, it has adverse effects on health. However, the accuracy of numerical dust models for predicting it is insufficient. One of the reasons is the lack of reliable estimates of the amount of dead vegetation over a broad area on the scale of the Gobi Desert. In this study, we measure the amount of dead vegetation in the Gobi Desert. Using this data, we establish a method to estimate the amount of dead vegetation for a broad area by the Soil Tillage Index (STI). Installing this dead vegetation data, we improve a numerical dust model.

スーダンおよびサブサハラアフリカの乾燥・高温農業生態系において持続的にコムギを生産するための革新的な気候変動耐性技術の開発
期間： 2018 年 4 月－ 2024 年 3 月
代表者：辻本壽
組織：鳥取大学（辻本壽、ヤシル・ゴラフィ、田中裕之、明石欣也、坪充 他）、宇都宮大学（岡本昌憲）、スーダン農業研究機構（イザット・タヘル他）、スーダン気象庁（A. M アブデルカリム他）
研究費：SATREPS
課題：本研究は、乾燥・高温耐性で、高栄養・高品質なコムギ品種を分子育種技術で迅速に開発し、情報通信技術で効果的に普及させることを目的としている。スーダンを含むサブサハラ地域は、今後最も栄養不足人口が増え、コムギに対する需要が特に高まっている。しかし、乾燥・高温環境が生産の障害となっている。そこで、これまでの研究で開発した乾燥・高温耐性コムギ系統を遺伝資源とし、実用品種を開発するための、育種基盤の構築を行っている。

Development of climate change resilient innovative technologies for suitable wheat production in the dry and heat prone agro-ecologies of Sudan and Sub-Saharan Africa
Period: Apr. 2018 - Mar. 2024
Leader: H. Tsujimoto (Tottori University)
Organization: Tottori University (H. Tsujimoto, Y. S. A. Gorafi, H. Tanaka, K. Akashi, M. Tsubo etc.), Utsunomiya University (M. Okamoto), Agricultural Research Corporation, Sudan (I. S. Tahir etc.), Sudan Meteorology Authority (A. M. Abdelkarim)
Funding: SATREPS
Subject: The goal of this research is to rapidly develop drought- and high-temperature-tolerant, highly nutritious, and high-quality wheat varieties using molecular breeding techniques and to effectively disseminate them using information and communication technology. The sub-Saharan region, including Sudan, will have the most malnourished population in the future and the demand for wheat is particularly high. However, the dry and hot environment is an obstacle to production. Therefore, the project is developing a breeding platform to develop practical varieties using the drought and high-temperature tolerant wheat lines developed in previous studies as genetic resources.

日本のコムギ研究リソースと国際農業研究機関の連結による新遺伝資源創出と育種展開
期間： 2019 年 10 月－ 2025 年 3 月
代表者：松岡由浩
組織：神戸大学（松岡由浩）、鳥取大学（辻本壽、石井孝佳、佐久間俊）、国際農研（岸井正浩）
研究費：日本学術振興会 科学研究費助成事業 国際共同研究加速基金（国際共同研究強化（B））
課題：本研究は、6 倍性パンコムギ（AABBDD ゲノム）に祖先野生種タルホコムギ（DD）のコアコレクションを交配・胚培養して、多数の「8 倍性合成コムギ（AABBDDDD）」を作出する。そして、タルホコムギの多様なアリルをパンコムギに導入して利用する新技術を開発し確立する。過去 100 年、コムギ染色体数の発見、倍数性進化の解明等、日本は世界の小麦研究をリードしており、最高水準の研究リソース（人材、技術、遺伝資源）を有する。本研究は、ゲノム解読が完了した好機に、研究リソースを結集し、気候変動下の食糧生産問題の解決に向けて、国際トウモロコシ・コムギ改良センター（CIMMYT、メキシコ）との共同研究を推進する。

カタールのパンコムギ耐性遺伝資源の開発と同定
期間： 2021 年 1 月－ 2023 年 12 月
代表者：辻本壽
組織：鳥取大学（辻本壽、ヤシル・ゴラフィ）、カタール大学（タラート･アハメッド、モハメッド･アルサフラン、ワリッド・クリア）
研究費：カタール大学・丸紅基金
課題：コムギは、カタールを含む世界の多くの国で、食料安全保障上の主要作物の一つである。カタールでは、小麦の国内需要を満たすために、主に輸入に依存している。カタールのコムギ生産量は非常に低く、耕作地と栽培地の変動に伴い、季節ごとに変動している。このように生産性が低いのは、パンコムギに適した品種や適切な生産技術がないことが主な原因である。そのため、高温ストレスに強い品種や、高温ストレスから逃れるために収量を落とさずに早熟する品種の開発が急務とされている。したがって、カタールにおける持続可能な小麦生産の道を開くためには、限られた水資源と貧弱な土壌を考慮して、よく適応した高収量の品種と生産技術を開発する必要がある。本研究では、ストレス条件下で開発・試験されたユニークなパンコムギ生殖質を用いて、カタールでの小麦生産と改良に適したパンコムギ生殖質を特定する。

生物的硝化抑制（BNI）技術を用いたヒンドゥスタン平原における窒素利用効率に優れたコムギ栽培体系の確立
期間： 2021 年 4 月－ 2026 年 3 月
代表者：飛田 哲
組織:JIRCAS（飛田哲 他）､鳥取大学（石井孝佳､辻本壽）､農研機構（寺沢洋平）､ボーローグ南アジア研究所（Uttam Kumar 他）
研究費：SATREPS
課題：作物生産で施用される窒素肥料の半分は植物に利用されず、水質汚染や温暖化ガスとして放出され環境に

New genetic resource development and advanced breeding through connecting the Japanese wheat research resources to a renowned international agricultural research institute
Period: Oct. 2019 - Mar. 2025
Leader: Y. Matsuoka (Kobe University)
Organization: Kobe University (Y. Matsuoka), Tottori University (H. Tsujimoto, T. Ishii, S. Sakuma), JIRCAS (M. Kishii)
Funding: Fund for the Promotion of Joint International Research (Fostering Joint International Research (B))
Subject: This research will cross and embryo culture a core collection of ancestral *Aegilops tauschii* (DD) with hexaploid bread wheat (AABBDD genome) to produce a series of "octoploid synthetic wheat (AABBDDDD)". Then, a new technology will be developed and established to introduce and utilize the diverse alleles of *Ae. tauschii* into bread wheat. For the past 100 years, Japan has led the world in wheat research in discovering the number of wheat chromosomes, elucidating the evolution of ploidy, etc., and has the highest level of research resources (human, technical, and genetic resources). This research will take advantage of the opportunity provided by the completion of genome sequencing to pool research resources and promote collaborative research with the International Maize and Wheat Improvement Center (CIMMYT, Mexico) to solve food production problems under climate change.

Development and identification of bread wheat resilient germplasm for Qatar
Period: Jan. 2021 - Dec. 2023
Leader: H. Tsujimoto (Tottori University)
Organization: Tottori University (H. Tsujimoto, Yasir, Y. S. Gorafi), Qatar University (Talaat A. Ahmed, Mohammed Al-Safran, Walid Kriaa)
Funding: QU Marubeni Grants
Subject: Wheat is one of the most important food security crops in many countries around the world, including Qatar. Qatar relies mainly on imports to meet its domestic demand for wheat. Wheat production in Qatar is very low and fluctuates seasonally due to changes in cultivated areas and cropping patterns. This low productivity is mainly due to the lack of suitable bread wheat varieties and appropriate production technology. Therefore, there is an urgent need to develop varieties that are tolerant to high temperature stress and varieties that can mature early without yield loss to escape high temperature stress. Therefore, well adapted high yielding varieties and production technologies need to be developed considering the limited water resources and poor soils to pave the way for sustainable wheat production in Qatar. This study will identify suitable bread wheat germplasm for wheat production and improvement in Qatar using unique bread wheat germplasm developed and tested under stress conditions.

Establishment of nitrogen-efficient wheat production systems in Indo-Gangetic Plains by the deployment of BNI-technology
Period: Apr. 2021 - Mar. 2026
Leader: S. Tobita (JIRCAS)
Organization: JIRCAS (S. Tobita et al.), Tottori University (T. Ishii, H. Tsujimoto), NARO (Y. Terasawa), Borlaug Institute for South Asia (Uttam Kumar et al.)
Funding: SATREPS
Subject: Half of the nitrogen fertilizer applied in crop production is not used by the plants and is released into the

悪影響を及ぼしている。本プロジェクトは、ハマニンニク（コムギの近縁野生種）の染色体断片をパンコムギに導入して開発された生物的硝化抑制機能をもつ系統を利用して、環境保全と共に、施肥量を減らして、生産にかかるコストを低減させることを目標として、インドのヒンドゥスタン平原において実証実験を行うものである。

groundwater and/or the air as greenhouse gases, causing environmental degradation. This project aims to reduce fertilizer application and production costs while protecting the environment by using a biological nitrification inhibition wheat line developed by introducing a chromosomal segment of Leymus species (wild ryegrass) into bread wheat and conducting a demonstration experiment in the Hindustan Plains of India.

パレスチナ西岸地区におけるウォーターハーベスティングによる食料安全保障の強化
期間：2016 年 4 月－ 2024 年 5 月
代表者：藤巻晴行（鳥取大学乾燥地研究センター）
組織：ナジャハ大学（Abdel Fattah El−Mallah）・鳥取大学乾燥地研究センター（藤巻晴行）
研究費：IPDRE シーズ創出研究プロジェクト
課題：パレスチナ西岸地区における食料安全保障の強化のため、ビニールシートおよび貯水槽を用いたウォーターハーベスティングの可能性を自動灌漑実験により評価する。

Enhancing food security using water harvesting in West Bank of Palestine
Period: Apr. 2016 - May 2024
Leader: H. Fujimaki (ALRC, Tottori University)
Organization: An-Najah University (Abdel Fattah El-Mallah), Tottori University (H. Fujimaki)
Funding: Development of crop husbandry technology in marginal lands using dryland plant resources
Subject: To enhance food security of Palestine, feasibility of new water harvesting method, water harvesting using plastic sheet and a reservoir, is evaluated through an automated irrigation experiment.

パレスチナにおけるナツメヤシの最適灌水基準サクションの探索
期間：2018 年 4 月－ 2025 年 9 月
代表者：藤巻晴行（鳥取大学乾燥地研究センター）
組織：パレスチナ国立農業研究所（R. Sameer）・鳥取大学乾燥地研究センター（藤巻晴行）、東海大学海洋学部（竹内真一）
研究費：IPDRE シーズ創出研究プロジェクト
課題：パレスチナ西岸地区における食料安全保障の強化のため、パレスチナ農業研究所ジェリコ支所内の実験圃場にて異なる 3 つの灌水基準サクションでナツメヤシを栽培している。

Optimization of trigger suction for automated irrigation to Date Palm in Palestine
Period: Apr. 2018 - Sep. 2025
Leader: H. Fujimaki (ALRC, Tottori University)
Organization: National Agricultural Research Center of Palestine (R. Sameer), Tottori University (H. Fujimaki), Tokai University (S. Takeuchi)
Funding: IPDRE (Innovation Research)
Subject: To enhance food security of Palestine, optimum trigger suction for Date Palm trees is searched by automatically irrigating with three different suctions in experimental orchard in Jericho station of NARC.

作物成長の数値モデルと天気予報を利用した灌漑水量の決定
期間：2017 年 11 月－ 2024 年 5 月
代表者：藤巻晴行（鳥取大学乾燥地研究センター）
組織：ICARDA（V. Nangia）・アラル海流域イノベーションセンター（I. Asanov）・鳥取大学乾燥地研究センター（藤巻晴行、Abd El Baki，H. M.）
研究費：IPDRE イノベーション創出研究プロジェクト、JSPS 国際共同研究加速基金（B）
課題：モロッコとウズベキスタンにおいて自動灌漑システムによる灌漑区と、数値予報と土壌物理シミュレーションモデルを組み合わせた灌漑水量決定（シミュレーション灌漑）に基づく灌漑区とで、仮想の価格設定による純収入を比較することにより、後者の効果を評価することを試みた。

Determination of irrigation depths using a numerical model of crop growth and quantitative weather forecast
Period: Nov. 2017 - May 2024
Leader: H. Fujimaki (ALRC, Tottori University)
Organization: ICARDA (V. Nangia), International Innovation Center for Aral Sea Basin (I. Asanov), Tottori University (H. Fujimaki, Abd El Baki, H.M.)
Funding: IPDRE (Innovation Research), JSPS (Fund for the Promotion of Joint International Research B)
Subject: Field experiments were carried out in Sudan and Morocco to evaluate the effectiveness of a new scheme to determine irrigation depths using a numerical model of crop growth and quantitative weather forecast in terms of net income considering the price of water.

ブラシノライドの施用が塩条件においてコムギの成長、栄養成分、抗酸化酵素活性および収量に対するストレス軽減効果
期間：2019 年 12 月－ 2023 年 3 月
代表者：V. Otie，ナイジェリア国カラバ大学
組織：ナイジェリア国カラバ大学（V. Otie）・鳥取大学乾燥地研究センター（安蒜）
研究費：カラバ大学
課題：ブラシノライドは、植物ホルモンの一種であり、

Elevating effects of brassinolide application on wheat growth, nutritional content, antioxidant activity and yield under saline conditions
Period: Dec. 2019 - Mar. 2023
Leader: V. Otie (University of Calabar, Nigeria)
Organization: University of Calabar (V. Otie), ALRC Tottori University (P. An)
Funding: University of Calabar
Subject: Brassinolide is a kind of plant hormone and has been reported to promote plant growth and induce stress tolerance.

植物の成長を促進し、ストレス耐性を誘導すると報告されている。しかし、塩ストレス条件において、その施用がダイズの成長に対する影響はまだ報告されていない。そこで、本研究を行い、ブラシノライドの施用が塩性条件下で栽培したダイズの成長に対する促進効果を検討した。実験 1：種子発芽実験：塩性条件下でブラシノライドを種子に施用し、グロースチャンバーを用い、種子の発芽率を調査した。本実験によりブラシノライドの種子発芽に対する塩害軽減効果を明らかにした。実験 2：最適施用量、施用時期、塩濃度実験：温室において塩性条件下でポット栽培を行った。ブラシノライドはダイズの出苗期、栄養成長期、開花期、収穫期に三濃度を施用してダイズの成長、生理学的、生化学的パラメーター、収量を測定し、ブラシノライドの最適施用時期および最適濃度を解明する本実験を行った。

渤海湾地域不均一な塩ストレスに対する植物の生理学的反応

期間：2019 年 4 月－ 2023 年 3 月
代表者：劉小京，中国科学院農業資源センター
組織：中国科学院農業資源センター（封暁輝，劉小京）・鳥取大学乾燥地研究センター（安萍）
研究費：中国科学院農業資源センター
課題：土壌中塩分の分布は、複雑な環境要因の相互作用により、空間的および時間的に常に変動します。植物は、不均一な塩分に対して従来と異なる反応を示す可能性があります。不均一な塩分に対してより良い成長反応を示す植物は、緑化などに利用することができます。

本研究の目的は、不均一な塩分環境に対する Hibiscus moscheutos の形態学的、解剖学的、および生理学的反応を調査することでした。均一な塩分よりも不均一な塩分環境で苗木がよく育つ場合は、この植物を利用して緑化を行うとき、部分的な低塩分ゾーンの作成、あるいは高塩分土壌の置換を行うことが重要になります。この研究から得られた知見は、実際の塩分を含んだ土地の緑化事業に直接利用できます。

塩水灌漑条件下で有機肥料を施用した砂質土壌からの栄養素の抽出、吸収およびリンチング

期間：2019 年 4 月－ 2023 年 3 月
代表者：M. Irshad，ペシャワール大学，パキスタン
組織：ペシャワール大学，パキスタン（M. Irshad）・鳥取大学乾燥地研究センター（安萍）
研究費：ペシャワール大学
課題：塩分集積土壌は地球規模の問題です。乾燥地の農業生産を改善するには、塩性土壌の有効利用が必要です。本研究は、土壌相内の植物栄養素の抽出性、ならびに異なる有機肥料および塩分レベルでの植物の根の選択性および養分輸送に対する影響を調査します。研究の目的は、1）塩性土壌での作物生産を向上するために、栄養素の投入量と灌漑水の最低水質の判明、2）砂質土壌による作物成長と栄養素のダイナミックとの関係を解明することです。

However, the effect of its application on soybean growth under salt stress conditions has not yet been reported. Therefore, this study was conducted to examine the effect of applying brassinolide on the growth of soybeans cultivated under saline conditions. Experiment 1: Seed germination experiment: Brassinolide was applied to seeds under saline conditions, and the germination rate of seeds was investigated using a growth chamber. This experiment showed the elevating effect of brassinolide on seed germination under salinity. Experiment 2: Optimal application amount, application time and salt concentration: Pot cultivation was carried out in a greenhouse under saline conditions. Brassinolide was applied at three concentrations during the seedling, vegetative growth, flowering and harvesting periods. Measurements included soybean growth, physiological and biochemical parameters and yield.

Physiological responses of plants grown in saline Bohai Bay to non-uniform salinity stress

Period: Apr. 2019 - Mar. 2023
Leader: Xiaojing Liu (Chinese Academy of Sciences (CAS))
Organization: Center for Agricultural Resources, CAS (X. Feng, X. Liu), ALRC Tottori University (P. An)
Funding: Center for Agricultural Resources, CAS
Subject: Salt distribution in soils is highly spatially and temporally variable due to the complex interactions of environmental factors. Plants may show differential responses to the heterogeneous salinity. The plants that show strongly positive growth response to the heterogeneous salinity may be utilized for greening or other purposes.

The aim of the joint study was to investigate the morphological, anatomical, and physiological responses of *Hibiscus moscheutos* to a non-uniform salinity environment. If the seedlings grow better under non- uniform salinity environment than under uniform salinity, then it will be important for creating a partial lower-salinity zones or conducting partial soil replacement to this plant in highly saline soil. The knowledge generated from this study can be directly translated into specific management measures for saline land revegetation and landscaping programs.

Extractability, bioavailability and leachability of plant nutrients from sand dune soil applied with organic manures under saline irrigation conditions

Period: Apr. 2019 - Mar. 2023
Leader: M. Irshad (University of Peshawar)
Organization: COSMAT University Islamabad, Pakistan (M. Irshad), ALRC Tottori University (P. An)
Funding: COSMAT University Islamabad
Subject: Salinity is a global problem. Reclamation of saline soils is necessary for improving agricultural production in drylands. The present study focused on the extractability of plant nutrients within the soil solid phase as well as root selectivity and translocation in plant at different organic manure and salinity levels. Objectives of the research study were to 1) improve production efficiencies in terms of nutrient inputs and marginal quality irrigation water for the enhancement of crop production in saline soils and 2) determine the effectiveness of organic manure on crop growth and nutrient bioavailability from sand dune soil irrigated with saline water.

ササゲの半数体作成法の確立
期間： 2022 年 4 月－ 2023 年 3 月
代表者：石井孝佳（鳥取大学乾燥地研究センター）
組織：鳥取大学乾燥地研究センター（石井孝佳）・ライプニッツ植物遺伝作物学研究所（アンドレアス･フウベン）・クイーンズランド大学（アンナ・コルツノフ）・コルテボア（マーク・アルバーソン）・ジョージア大学（ペギー・オジアスーアキンス）・ランヒビオ－シンベスタ（ジョアン・フィリップ）・チューリッヒ大学（ウリ・グラウスニコラウス）
研究費：クイーンズランド大学（ビル＆メリンダ・ゲイツ財団助成金）
課題：ササゲ（*Vigna unguiculata*、2n=2x=22）は、アフリカで重要なマメ科作物であり、干ばつや熱ストレスに対して強い耐性を持っている。 半数体（倍加半数体）は、植物育種を促進するのに非常に強力な手法である。 本共同研究では、セントロメア特異的ヒストン H3（CENH3）の操作によるササゲの半数体生産法を確立する事を目標にした。ササゲは、二倍体ゲノム中に 2 種類の CENH3 をコードしていることが分かった。 ササゲ半数体誘導系統の作成のための CENH3 の改変は現在進行中である。

インドのための BNI コムギ
期間： 2022 年 4 月－ 2023 年 3 月
代表者：石井孝佳（鳥取大学乾燥地研究センター）
組織：鳥取大学乾燥地研究センター（石井孝佳）・国立研究開発法人農業･食品産業技術総合研究機構（寺沢洋平）・日本大学（飛田哲）･コルテボア（マーク･アルバーソン）・ジョージア
研究費：JST（SATREPS）
課題：コムギは非常に重要な作物である。コムギ近縁野生種の *Leymus racemosus*（2n=4x=28）の持つ生物的硝化抑制（BNI）遺伝子を遠縁交雑によって導入したコムギが近年開発された。BNI 効果によりコムギへの窒素肥料の施肥量が減少する事が明らかになっている。よって、BNI による持続可能な食糧体系の構築が可能になる事が予想される。本研究では BNI 効果を持つコムギをインドに適応する。

コムギ育種のための新奇 8 倍体コムギ作成
期間： 2022 年 4 月－ 2023 年 3 月
代表者：石井孝佳（鳥取大学乾燥地研究センター）
組織:鳥取大学乾燥地研究センター（石井孝佳、辻本壽)・鳥取大学（佐久間俊）・神戸大学（松岡由浩）・CIMMIY/JIRCAS（岸井正浩）
研究費：JSPS（国際共同研究強化 B）
課題：コムギは非常に重要な作物である。一方で、コムギは進化の過程で D ゲノムの遺伝的多様性が非常に小さくなってしまっている。コムギ近縁野生種のタルホコムギ *Aegilops tauschii*（2n=2x=14）はパンコムギの D ゲノムの供給親である。我々は、遠縁交雑方法を用いて、コムギとタルホコムギを交雑した 8 倍体コムギを多数作成している。これらの 8 倍体コムギは将来、頑健なパンコムギを創り出すための育種材料になる事が予想される。

Establishment of haploid inducer in cowpea
Period: Apr. 2022 - Mar. 2023
Leader: T. Ishii (ALRC, Tottori University)
Organization: Tottori University (T. Ishii), Leibniz Institute of Plant Genetics and Crop Plant Research, Germany (Andreas Houben), The University of Queensland (Anna Koltunow), The University of Georgia (Peggy Ozias-Akins), Langebio Cinvestav (Jean Philippe Vielle Calzada), The University of Zurich (Ueli Grossniklaus)
Funding: Sub-award from the University of Queensland for the grant 'Hy-Gain for smallholders' from the Bill & Melinda Gates Foundation (USA).
Subject: Cowpea (*Vigna unguiculata*, 2n=2x=22) is an important legume crop in Africa, and has a pronounced tolerance to drought and heat stress. Haploids (doubled haploids) are very instrumental to accelerate the plant breeding process. We intend to establish a haploid production method for cowpea via manipulation of the centromere-specific histone H3 (CENH3) variant. Cowpea encodes two types of CENH3s in the diploid genome. Manipulation of cowpea CENH3s is in progress.

BNI wheat for India
Period: Apr. 2022 - Mar. 2023
Sub-Leader: T. Ishii (ALRC, Tottori University)
Organization: Tottori University (T. Ishii), NARO (Y. Terasawa) and Nihon University (S. Tobita)
Funding: JST SATREPS (Japan).
Subject: Wheat (*Triticum aestivum*, 2n=6x=42) is an important crop all over the world. Biological Nitrification Inhibition (BNI) was found in *Leymus racemosus* (2n=4x=28) and transferred to the wheat via a wide hybridization method. BNI reduces the nitrogen fertilization use for wheat. BNI-wheat will make it possible for a sustainable agriculture system in future. We are aiming to introduce BNI wheat into India.

Octaproid wheat for the novel genetic resource of bread wheat
Period: Apr. 2022 - Mar. 2023
Sub-Leader: T. Ishii (ALRC, Tottori University)
Organization: Tottori University (T. Ishii, H. Tsujimoto and S. Sakuma), Kobe University (Y. Matsuoka) and CIMMYT/JIRCAS (M. Kishii)
Funding: JSPS Fostering Joint International Research (B) (Japan).
Subject: Wheat (*Triticum aestivum*, 2n=6x=42) is an important crop all over the world. However, genetic diversity of wheat D gene is very low due to the genetic bottleneck during the evolution. *Aegilops tauschii* (2n=2x=14) is a wheat D genome donor. We are producing a lot of octaproid wheat via wide hybridization method using *Ae. tauschii* to introduce genetic diversity into wheat. Novel genetic material will use for the production of resilient wheat for the future.

コムギ育種のための新奇８倍体コムギ作成
期間： 2022 年 4 月－ 2023 年 3 月
代表者：石井孝佳（鳥取大学乾燥地研究センター）
組織：鳥取大学乾燥地研究センター（石井孝佳）、鳥取大学国際乾燥地研究教育機構（ヤシル・ゴラフィ）、スーダン ARC
研究費：JST（FOREST）
課題：作物の改良には、交雑によって遺伝的多様性を高めることが不可欠である。しかし、遠く離れた種から目的の雑種を作り出すことは、生殖障壁のために困難である場合がおおい。染色体脱落の操作が可能になれば、作物の遺伝的多様性を爆発的に増大させる。そこで本プロジェクトでは、エンバクやコムギと数種類のペニセタムとの交配をモデルとして染色体除去の研究を行う。染色体除去のメカニズムを解明し、胚発生初期に染色体を操作する。

パンコムギのキャノピー温度関連形質とその多面発現効果の遺伝育種的解析
期間： 2018 年 4 月－ 2023 年 6 月
代表者：山崎裕司（鳥取大学乾燥地研究センター）
組織：鳥取大学乾燥地研究センター（山崎裕司）・スーダン農業研究機構（イザット・タヘル）
研究費：科研費若手、SATREPS
課題： 特定の合成コムギから派生した系統の中に、キャノピー温度と収量の負の相関性が高いものがあり、その集団の中には、それらの多面発現効果を有する QTLs が存在すると考えられることから、キャノピー温度と収量に関する複数の QTL 解析を通し多面発現効果を持つ QTL のネットワークの解明を行う。

微気象観測のための Europian ネットワーク
期間：2021 年 5 月－ 2025 年 10 月
代表者 : B. Lalic (University of Novi sad, Serbia), Levent Şaylan (Management Committee Member of Türkiye)
組織：EU COST action (European Cooperation in Science and Technology). Istanbul technical University (Levent Şaylan, Baris Caldag), University of Novi sad (Branka Lalic), University of Natural Resources and Life sci. (Josef Eitzinger) and other universities and research organizations from different countries.
研究費：EU COST Action
課題：天候による農業損失、灌漑のための水使用、病気を媒介する侵入者の出現、植物病害や害虫、森林破壊、都市化、農村から都市への移動、および冷却・暖房のための都市エネルギー消費の増加に対して、微気象学的知識共有プラットフォームが必要とされている。本ネットワークの目的は､データベースの構築や微気象ステーションの配置、および農業気象学や都市の微気候モニタリングのために設定した観測ネットワークの標準化と統合を改善することである。

Octaproid wheat for the novel genetic resource of bread wheat
Period: Apr. 2022 - Mar. 2023
Leader: T. Ishii (ALRC, Tottori University)
Organization: Tottori University (T. Ishii, Yasir, S. A. Gorafi) , Gene bank (ARC, Sudan)
Funding: JST FOREST (Japan).
Subject: Increasing genetic diversity through widespread hybridization is essential for crop improvement. However, the production of the desired hybrid from distant species is difficult due to several reproductive barriers. Manipulation of chromosome elimination will greatly increase the genetic diversity of crops in the future. Therefore, in this project, oat or wheat crosses with several different Pennisetum are the model for the chromosome elimination study. To elucidate the mechanism of chromosome elimination and to manipulate the chromosome during early embryogenesis.

Breeding analysis for pleiotropic effects on canopy temperature and related traits in bread wheat
Period: Apr. 2018 - June. 2023
Leader: Y. Yamasaki (ALRC, Tottori University)
Organization: Tottori University (Y. Yamasaki), Agricultural Research Corporation, Sudan (Izzat S. A. Tahir)
Funding: Kakenhi (2018-2021), SATREPS (2021-2023)
Subject: Some genotypes derived from specific synthetic wheat were confirmed to have strong negative correlation between canopy temperature and grain yield. This study will reveal identification and network of QTLs regulating canopy temperature and grain yield as pleiotropic effects.

The European Network for FAIR NEtwork of micrometeorological measurements (FAIRNESS) (CA20108)
Period: May 2021 - Oct. 2025
Leader: B. Lalic (University of Novi sad, Serbia). Levent Şaylan (Management Committee Member of Türkiye)
Organization: EU COST action (European Cooperation in Science and Technology). Istanbul technical University (Levent Şaylan, Baris Caldag), University of Novi sad (Branka Lalic), University of Natural Resources and Life sci. (Josef Eitzinger) and other universities and research organizations from different countries.
Funding: EU COST Action
Subject: The current state of weather-induced agricultural losses, water use for irrigation, the appearance of new invasive species and disease vectors (strongly depending on micrometeorological conditions), new environmental zoning of plant diseases and pests, deforestation, increased urbanization, rural-to-urban migration and increased urban energy consumption for cooling/heating impose scientific and societal request to provide micrometeorological knowledge share platform (Micromet_KSP) in order to communicate: a) compiled an inventory of available and quality proven micrometeorological in situ data sets on the European level and beyond, b) measurement and data management recommendations designed in order to meet FAIR principles and avoid temporal and spatial gaps, c) examples of rural and urban FAIR data sets and d) Q&A exchanged between Action members, stakeholders, specialized user groups and the general

public. The FAIRNESS action intends to improve standardization and integration between databases/sets of micrometeorological measurements that are part of research projects or local/regional observational networks established for special purposes (agrometeorology, urban microclimate monitoring). Addressing identified challenges requires an effective transboundary network of researchers, stakeholders (extension services and environmental agencies, local authorities and ministries, SME) and civil society (specialized and general public) from Europe and beyond to identify and fill knowledge gaps, standardize, optimize and promote new environmental-tailored measurement and control procedures, enhance research effectiveness and improve dissemination.

農業に関する気候変動適応のための革新的な VET 視点
期間：2022 年 2 月－ 2024 年 10 月
代表者：Municipality of Silivri, Istanbul, Türkiye (Levent Saylan (Project partner) for Istanbul Technical University)
組織：EU Erasmus+ Project Partners: Istanbul Technical University (Levent Saylan, Baris Caldag), Eu&Pro Centrum Vzdělávání A Praxe, S.R.O.; University of Natural Resources and Life Science, Vienna, Austria; The Polish Farm Advisory znd Training Center Not-For-Profit Sp. Z O. He. Poland, Tekirdag Namik Kemal University, Türkiye.
研究費：EU Erasmus
課題：プロジェクトの目的は、持続可能な農業用水管理と農業気象リテラシーに取り組むことにより、農業に関する VET 学習を通じて気候変動への適応と回復力を高めることである。具体的には、農業気象リテラシーと持続可能な灌漑管理システムに関して、VET を学ぶ学生の能力とスキルのレベルを向上させること、VET の指導者に、農業気象リテラシー、新しい灌漑方法、スマート農業および農業における気候変動適応政策に関する教材と革新的なトレーニングツールを提供することである。

An Innovative VET Perspective on Agriculture for Climate Change Adaptation
Period: Feb. 2022 - Oct. 2024
Erasmus+ EU project. Project title:. Project leader: Municipality of Silivri in Istanbul.
Leader: Municipality of Silivri, Istanbul, Türkiye
(Levent Saylan (Project partner) for Istanbul Technical University)
Organization: EU Erasmus+ Project Partners: Istanbul Technical University (Levent Saylan, Baris Caldag), Eu&Pro Centrum Vzdělávání A Praxe, S.R.O.; University of Natural Resources and Life Science, Vienna, Austria; The Polish Farm Advisory znd Training Center Not-For-Profit Sp. Z O. He. Poland, Tekirdag Namik Kemal University, Türkiye.
Funding: EU Erasmus+
Subject: Our project aims to enhance climate change adaptation and resilience through VET learning on agriculture by addressing sustainable agricultural water management and agrometeorological literacy. The specific aims are: To improve the level of competencies and skills of VET students on agrometeorological literacy and sustainable irrigation management system. To equip VET teachers with educational materials and innovative training tools on agrometeorological literacy, new irrigation methods, smart farming and policies for climate change adaptation in agriculture. To raise an awareness of the significance of climate change adaptation on agriculture.

Climate change impact on sedimentation risk of reservoirs in the Upper Blue Nile basin
Period: Oct. 2021 - Sep. 2025
Leader: Prof. A. Tsunekawa (ALRC, Tottori University)
Organization: Tottori University (A. Tsunekawa, Nigussie Haregeweyen Ayele A. Fenta, Mulatu L.Berihun), Blue Nile Water Institute Bahir Dar University, Ethiopia (Dagnachew Aklog)
Funding: Grants-in-Aid for Scientific Research, KAKENHI (Joint International Research (B))
Subject: To develop empirical model that will predict sediment yield and water quality in Lake Tana basin by integrating field-based measurement and remote sensing imageries to combat the effect of climate extremes on the reservoirs.

（3）外国人研究者・外国人受託研修員・研究生の受入れ

外国人研究者

Xin Long
（令和 2 年 10 月 1 日～令和 5 年 8 月 31 日）
アデレード大学心理学部・大学院生
私費

Hamideh Noory
（令和 4 年 4 月 1 日～令和 5 年 3 月 31 日）
テヘラン大学農業・自然資源学部・准教授
私費

Zafarjon Ziyaev Mashrapovich
（令和 4 年 5 月 13 日～令和 4 年 8 月 4 日）
ウズベキスタン科学アカデミー遺伝学・植物実験生物学研究所（IGPEB）・上席研究員
IGPEB 経費

Nouralhuda Abdalla Jubara Tia
（令和 4 年 8 月 1 日～令和 6 年 3 月 31 日）
スーダン農業研究機構植物栄養部門・研究員
私費

Ali Mahmoud Muddathir Mahmoud
（令和 4 年 8 月 25 日～令和 4 年 11 月 21 日）
ハルツーム大学農学部園芸学科・准教授
鳥取大学乾燥地研究センター・海外研究者招聘型共同研究経費

Chuanhua Li
（令和 4 年 8 月 26 日～令和 5 年 8 月 25 日）
西北師範大学地理環境科学部・准教授
私費

外国人受託研修員

令和 4 年度 JICA 国別研修 「節水灌漑システム普及」（令和 4 年 10 月 23 日～令和 4 年 11 月 5 日）モロッコ 12 名

研究生

Alebachew Tareke Kehali
（令和 3 年 10 月 1 日～令和 4 年 9 月 30 日）エチオピア
Amir Ibrahim Ismail Emam
（令和 3 年 10 月 1 日～令和 4 年 9 月 30 日）スーダン
Samuel Berihun Kassa
（令和 4 年 10 月 1 日～令和 5 年 9 月 30 日）エチオピア

(3) Visiting Researchers, Visiting Training Participants and Research Students

Visiting Researchers

Xin Long
(Oct. 1, 2020 – Aug. 31, 2023)
Graduate student, School of Psychology, the University of Adelaide, Australia
Private funds

Hamideh Noory
(Apr. 1, 2022 – Mar. 31, 2023)
Associate Professor, Faculty of Agriculture Engineering and Technology, University College of Agriculture and Natural Reseources, University of Tehran, Iran
Private funds

Zafarjon Ziyaev Mashrapovich
(May 13, 2022 – Aug. 4, 2022)
Senior Scientist, Institute of Genetics and Plant Experimental Biology (IGPEB), Academy of Sciences of the Republic of Uzbekistan
Funded by IGPEB

Nouralhuda Abdalla Jubara Tia
(Aug. 1, 2022 – Mar. 31, 2024)
Researcher, Plant Nutrition Department, Agricultural Research Corporation, Sudan
Private funds

Ali Mahmoud Muddathir Mahmoud
(Aug. 25, 2022 – Nov. 21, 2022)
Associate Professor, Department of Horticulture, Faculty of Agriculture, University of Khartoum
Funded by Guest Research Associate for Joint Research Program, Arid Land Research Center, Tottori University

Chuanhua Li
(Aug. 26, 2022 – Aug. 25, 2023)
Associate Professor, College of Geography and Environmental Science, Northwest Normal University, China
Private funds

Visiting Training Participants

JICA Country-Focused Knowledge Co-Creation Program for Morocco in FY 2022, “Dissemination of water-saving irrigation systems” (Oct. 23, 2022 – Nov. 5, 2022)
12 Moroccans

Research Students

Alebachew Tareke Kehali
(Oct. 1, 2021 – Sep. 30, 2022) Ethiopia
Amir Ibrahim Ismail Emam
(Oct. 1, 2021 – Sep. 30, 2022) Sudan
Samuel Berihun Kassa
(Oct. 1, 2022 – Sep. 30, 2023) Ethiopia