1. 研究活動（2021 年 4 月～ 2022 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 等からの外国人委託研究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。

本センターでは、「乾燥地植物資源を活用した天水栽培限界地における作物生産技術の開発－世界の耕作限界地における持続的開発を目指して－（限界地プロジェクト第 1 期）」を平成 27 年度から平成 30 年度までの 4 年間実施した。第 2 期（令和元年度～令和 3 年度）では、副題を「－世界の耕作限界地における挑戦と実証－」に変更し、耕作限界地において安定・持続的な農業生産を可能にする、「発展型技術パッケージ」の開発を行っている。

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。

また、共同利用・共同研究拠点強化プロジェクト「砂漠化地域における地球温暖化への対応に関する研究（乾燥地 × 温暖化プロジェクト）」（平成 29 年度～令和 3 年度）においては、将来気候グループ、砂漠化対処グループ、乾燥地農業グループの 3 つのグループで研究活動を推進している。令和 4 年 3 月には 5 年間のプロジェクト成果をまとめた書籍「気候変動と乾燥地：研究の最前線から」を丸善出版（株）より出版した。

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）が、JST の 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。

乾燥地研究センターの坪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

1. Research Overview (April 2021–March 2022)

1.1 Outlines of Research Activities

(1) About Arid Land Research Center

The Arid Land Research Center (ALRC) is an independent department of Tottori University and, at the same time, is a Joint Usage/ Research Center. The mission of ALRC is to conduct research on desertification and to develop sustainable agricultural practices in arid and semi-arid areas. The door is open to all researchers who are engaged in the field of Dryland Science.

The goals of the establishment of the Center are, with regard to research, to advance knowledge and technologies concerning plant production and revegetation of deserts, which the Arid Land Research Center and its predecessor have accumulated, so it can be widely applied to arid land soils around the world. Simultaneously, blending this with knowledge and technologies in the social economics and medical fields etc., to build a new Science of Arid Land that contribute to combat global desertification and ensure people's healthy daily lives. In the educational field, ALRC's mission is to nurture researchers and advance technologists to deal with arid lands that are required by international organizations, private companies, NGOs etc. through educating graduate students (Master's and Doctoral courses), research students, and international researchers from Japan International Cooperation Agency (JICA), etc.

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.

ALRC had implemented the Project Marginal Region Agriculture's 1st phase, "Development of crop husbandry technology in marginal rainfed environment using dryland plant resources - Toward sustainable improvement in global marginal regions," for four years from FY2015 through FY2018. In the 2nd phase of this project (FY2019 - FY2021), the subtitle of the project was changed to "Challenges and Demonstration in the Global Marginal Regions" to develop an "advanced technology package" that will enable stable and sustainable agricultural production in the rainfed cultivation lands.

ALRC's Professor Atsushi Tsunekawa's research project entitled "Development of Next-Generation Sustainable Land Management (SLM) Framework to Combat Desertification" was selected as one of the FY2016 Science and Technology Research Partnership for Sustainable Development (SATREPS) programs by Japan Science and Technology Agency (JST). Full-scale operation of the five-year project has started from FY2017 in partnership with Bahir Dar University, Ethiopia.

ALRC has launched its five-year project entitled "Impacts of Climate Change on Drylands: Assessment and Adaptation (Project ICC×DRYLANDs)" since FY2017, aiming to enhance its function as a Joint Usage / Research Center. This project has been actively promoted by our three research groups: Future Climate Group, Combat Desertification Group, and Dryland Agriculture Group. In March 2022, we published a book entitled "Climate Change and Drylands: The Cutting Edge of Research," from Maruzen Publishing Co. It summarized the outcomes of our five-year project.

Furthermore, ALRC's professor Hisashi Tsujimoto's five-year 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" was selected as one of the FY2018 SATREPS programs by JST. The research team has started full-

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、JST の戦略的国際共同研究プログラムである AJ-CORE（Africa-Japan Collaborative Research）に採択され、共同研究が開始された。

乾燥地研究センターの石井孝佳講師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 4 月から研究が開始された。

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 6 月にキックオフ・ワークショップがオンラインで開催された。

元乾燥地研究センター長の神近牧男名誉教授が、令和 3 年度春の叙勲で瑞宝中綬章を受章した。

令和 3 年 9 月、乾燥地研究センターの恒川篤史教授が、長年携わってきた乾燥地科学研究、教育及び人材育成における貢献を高く評価され、エチオピア・バハルダール大学の名誉博士号を受章した。

乾燥地研究センターの石井孝佳講師が、東京都立大学大学院理学研究科の Tety Maryenti 氏、岡本龍史教授と共同で、世界で初めてコムギとイネの交雑植物の作出に成功した。この研究結果は、コムギとイネの遺伝資源の相互利用に向けた大きな一歩であり、新たな育種技術としても期待される。

令和 4 年 3 月、乾燥地研究センターの石井孝佳講師が、雑種胚細胞で起こる染色体脱落の理解と育種的利用に関する研究業績を高く評価され、令和 3 年度日本育種学会奨励賞を受賞した。

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 研究部門、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。

研究部門は、総合的砂漠化対処部門、環境保全部門、農業生産部門の 3 研究部門から構成され、専任の教授 6 名、准教授 4 名、助教 1 名、講師 1 名、特命助教 6 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 5 名が配置された。事務系には職員 17 名 (事務職員 6 名、事務補佐員 11 名)、技術系には職員 11 名 (技術職員 4 名、技術補佐員 7 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 4 年 3 月 31 日時点）。

共同研究、教育、刊行物

令和 3 年度における共同利用研究代表者 (大学教員など) は 61 名、指導学生数は 39 名 (博士課程 22 名、修士課程 13 名、学部学生 1 名、研究生 3 名、うち留学生 28 名（中国 5 名、エチオピア 8 名、スーダン 8 名、ナイジェリア 2 名、モンゴル 1 名、バングラデシュ 1 名、ケニア 2 名、ブルキナファソ 1 名）) である。

fledged operations from FY2019 jointly with Agricultural Research Corporation and Metrological Authority, Sudan.

The research project entitled “Development of Resilient E-farming for agro-climate risk management in African Multi-environment (DREAM)”, which is led by Prof. Tsubo of ALRC, was selected as AJ-CORE (Africa-Japan Collaborative Research) of JST’s Strategic International Collaborative Research Program, and the joint research started.

A JST FOREST research project entitled "Expansion of Genetic Resource Concept by Overcoming Chromosome elimination" led by Dr. Takayoshi Ishii was approved. The FOREST project will support Dr. Ishii for 2021 to 2028.

ALRC’s professor Norikazu Yamanaka’s research project entitled “Climate resilience and productivity of halophytes in Turanian-Eurasian Ecosystems” was selected as FY2021 Japan-Russia Research Cooperative Program between JSPS and RFBR. A kick-off workshop was held online in June 2021.

Tottori University’s Emeritus Professor Makio Kamichika, former director of the ALRC, received The Order of the Sacred Treasure, Gold Rays with Neck Ribbon at the 2021 Spring Conferment of Decoration.

In September 2021, ALRC’s Professor Atsushi Tsunekawa received an honorary doctorate from Bahir Dar University in Ethiopia for his highly evaluated achievements in dryland science research, education, and human resource development over many years.

ALRC’s Junior Associate Professor Takayoshi Ishii in collaboration with Tety Maryenti and Professor Takashi Okamoto at the Department of Biological Sciences, Tokyo Metropolitan University successfully produced the world’s first wheat-rice hybrid plants. This research outcome is a major step towards expanding the utilization of wheat and rice genetic resources across genera and is also expected to be a promising novel breeding technology.

In March 2022, ALRC’s Junior Associate Professor Takayoshi Ishii received the “Young Scientist Award” of the Japanese Society of Breeding for his highly evaluated research achievements on understanding chromosome elimination in hybrid embryo cells for innovations in plant breeding.

Organization and Management Structure

ALRC consists of the Director, Vice Director, Faculty Meeting, Advisory Committee, Joint Research Committee, Research Division, the Laboratory of Arid Land Plant Resources, and the Administration Department. The Faculty Meeting and the Advisory Committee operate the center. 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: Integrated Desertification Control Division, Environmental Conservation Division, and Agricultural Production Division. As of March 31, 2022, six full-time professors, four associate professors, one assistant professor, one junior associate professor, six specially appointed assistant professors, four visiting professors from Japan and three foreign research scholars were allocated to these research divisions. In addition, five project researchers were added to our research teams. Moreover, 17 office staff (six full-time and 11 part-time) and 11 technical staff (four full-time and seven part-time) supported ALRC’s research and education.

Joint Research, Education, Publication

In FY2021, 61 joint-use research principal investigators, mainly from national and private universities, were attached to

共同研究に関する研究発表会は毎年開催しており、令和 3 年度は、新型コロナウイルス感染症の終息時期が見込めなかったため、12 月 4 日にオンライン形式で開催した。

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、広報誌を年数回発行し、最新の活動状況等を紹介している。

この他、令和 3 年度には、以下の刊行物を出版した。

- 乾燥地フォトブックシリーズ vol.6　乾燥地の自然と暮らし―中国・ムウス砂地―（吉川賢・山中典和著、鳥取大学乾燥地研究センター監修、今井出版、令和 4 年 3 月出版）
- 気候変動と乾燥地　研究の最前線から（鳥取大学乾燥地研究センター監修、坪充・黒崎泰典・衣笠利彦 編、丸善出版、令和 4 年 3 月出版）

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 3 年度は新型コロナウイルスの世界的感染拡大の影響により、国内外における様々な活動が延期・中止を余儀なくされた。しかし、このような状況下においてもオンラインで研究成果の発信や一般公開等を実施している。

令和 3 年度の主な活動は以下のとおり。

- JST ジュニアドクター育成塾「めざせ！地球を救う環境博士」：令和 3 年 10 月 31 日、参加人数 20 名
- 一般公開：新型コロナウイルス感染症拡大防止のため、対面による一般公開は実施せず、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

ALRC. In addition, ALRC had a total of 39 students; 22 Ph.D. students, 13 master's students, one undergraduate student and three research students. Of them, 28 students were from overseas; five Chinese, eight Ethiopian, eight Sudanese, two Nigerian, one Mongolian, one Bangladeshi, two Kenyan, and one Burkinan.

ALRC holds the Joint Research Symposium every year. In FY2021, we held the symposium online on December 4 since the end of the Covid-19 was not expected.

Concerning education, the course "Global Dryland Science" was established for Master's course (Graduate School of 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 ALRC's research and education activities. In addition, ALRC issues newsletters several times a year to introduce its latest research activities, supported by the "Tottori Kanchiken Club" established by a local business association.

Moreover, ALRC issued the following publication in FY 2021.

- Photobooks of Drylands vol.6: Nature and Life in Drylands - Mu Us Sandy Land, China - (Yoshikawa, K. and Yamanaka, N., Published by IMAISHUPPAN, March 2022.)
- Climate Change and Drylands - The Cutting Edge of Research (Supervision: ALRC, Editor: Tsubo, M., Kurosaki, Y. and Kinugasa, T., Published by Maruzen Publishing Co.Ltd., March 2022)

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 FY2021, various activities in Japan and abroad had to be postponed or cancelled due to the global spread of the Covid-19. However, even under these circumstances, ALRC has been disseminating ALRC's research results online and making them available to the public.

We held the following activities during FY2021.

- Jr-Doctor Training School "Let's go! Dr. Environment to Save the Earth": October 31, 2021, ALRC
- Open House Event: In order to prevent the spread of the Covid-19, ALRC was not open to the public in person, but a video introducing the ALRC was made available on YouTube, and a tour of the Arid Dome was conducted 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）研究部門

1）総合的砂漠化対処部門

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、ポリアクリルアミド（PAM）の効果について以下のような研究結果を得た。

本研究は、ポリアクリルアミド（PAM）単独または他の土壌改良材との組み合わせが、土壌肥沃度とテフ（*Eragrostis tef* (Zucc.) Trotter）の収量に及ぼす影響を調査することを目的とした。エチオピアの青ナイル上流域の対照的な 3 つの農業生態系ゾーンにおいて、3 反復の無作為完全ブロック計画を用いて、2 年間のフィールド実験を実施した。適用した改良剤は、PAM（40 kg ha^{-1} ）、バイオ炭（B、8 t ha^{-1}）、石灰（L、4 t ha^{-1}）、石膏（G、5 t ha^{-1}）、堆肥（FYM、5 t ha^{-1}）、PAM+ B、PAM+ L、PAM+ G、対照とした。その結果、アバガリマ土壌とグダル土壌では、PAM ＋ L、PAM ＋ B、L 処理が pH、有効リン（Pav）、全窒素（TN）、有機炭素、水浸透を顕著に改善したのに対し、ドゥバテ土壌では PAM ＋ B、B、FYM 処理が土壌水分量、Pav、TN を明確に増加させることが明らかとなった。同様に、対照区と比較して、テフ収量はグダルで約 25 ～ 37％、アバガリマで 25 ～ 32％、ドゥバテで 20 ～ 31％有意に増加した（$p<0.05$）。

Mulualem T, Adgo E, Meshesha DT, Tsunekawa A, Haregeweyn N, Tsubo M, Kebede B, Mamedov AI, Masunaga T, Berihun ML. MAY 2021 (early access). Examining the impact of polyacrylamide and other soil amendments on soil fertility and crop yield in contrasting agroecological environments. Journal of Soil Science and Plant Nutrition. doi: 10.1007/s42729-021-00482-4.

(2) Research Divisions

1) Integrated Desertification Control Division

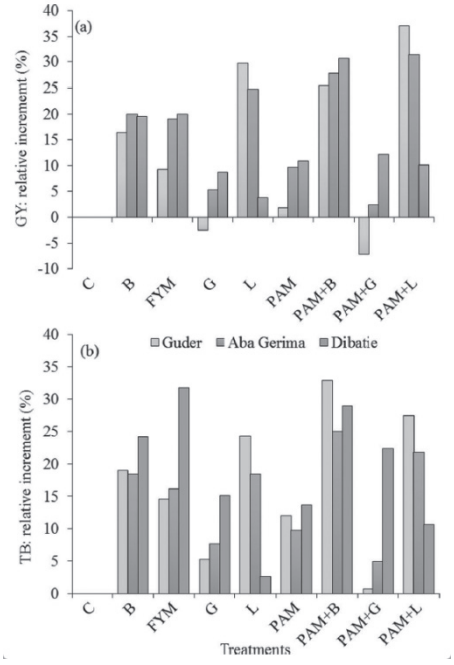
Atsushi Tsunekawa (Prof., Conservation Informatics)

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 effects of Polyacrylamide (PAM) by the field experiment in Ethiopia.

This study aims to investigate the effects of polyacrylamide (PAM) alone or integrated with other soil amendments on soil fertility and Teff (Eragrostis tef (Zucc.) Trotter) yield. A field experiment was carried out for 2 years in three contrasting agroecological zones of the Upper Blue Nile basin, Ethiopia, using a randomized complete block design with 3 replicates. The amendments applied were PAM (40 kg ha^{-1}), biochar (B, 8 t ha^{-1}), lime (L, 4 t ha^{-1}), gypsum (G, 5 t ha^{-1}), farmyard manure (FYM, 5 t ha^{-1}), PAM+ B, PAM+ L, and PAM+ G, and control. The results showed that PAM+ L, PAM+ B, and L treatments noticeably improved pH, available phosphorus (P 砂 total nitrogen (TN), organic carbon, and water infiltration in the Aba Gerima and Guder soils, whereas the PAM + B, B, and FYM treatments expressively increased soil water content, Pav, and TN in the Dibatie soil. Likewise, compared with the control, teff yield significantly ($p < 0.05$) increased by about 25 to 37% at Guder, 25 to 32% at Aba Gerima, and 20 to 31% at Dibatie.



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、特に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

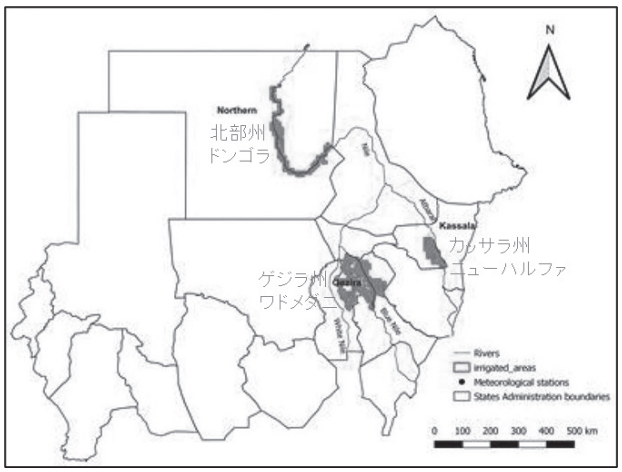
今年度は、次の研究を行った。

コムギ収量と気温の回帰分析

スーダンの高温乾燥地における灌漑栽培コムギの収量と生育期にあたる 11 月から 2 月の気温との関係を明らかにした。回帰分析の結果､3 つの全ての灌漑地（ドンゴラ、ワドメダニおよびニューハルファ）で、生育期の気温の上昇傾向が検出された。収量は生育期の気温と負の相関を示し、特に北部州の最低気温が 20℃以上となった日の発生頻度、ゲジラ州の最高気温およびカッサラの最低気温との相関が顕著であった。これらの結果から、スーダンにおけるコムギ収量の低下は、近年の生育期における気温上昇に起因する可能性があるということが示唆された。

降雨データのダウンスケーリング

スーダンの異なる気候帯における、夏作物の収量の決定要因である雨期（6 月～ 9 月）の降雨量について、Weather Research and Forecasting（WRF）モデルにおいて最適な積雲パラメータ化スキームを選定した。ダウンスケール実験では、Betts–Miller–Janjic（BMJ）、改良型 Kain–Fritch（KFT）、修正型 Tiedtke、および Grell–Freitas の各スキームを比較した。その結果、極乾燥地帯および乾燥地帯の雨季の降雨に対して BMJ がより良いパフォーマンスを示し、KFT は夏作物のほとんどが栽培される半乾燥地帯の 7 月と 8 月の降雨量に対してより良いパフォーマンスを示した。したがって、スーダンの特定の気候帯に対しては、特定の積雲パラメータ化スキームを選択する必要があるといえる。



スーダンのコムギ生産地
Wheat-producing areas in Sudan

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

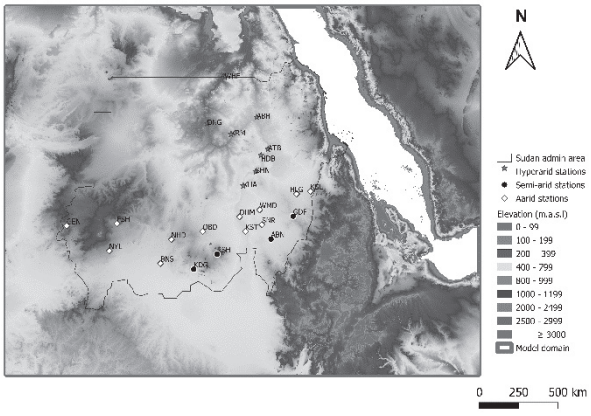
Research activities in this fiscal year were as follows.

Regression analysis between wheat yield and temperature

The relationship between yield of irrigated wheat in hot drylands of Sudan and temperature during the growing season (November–February) was determined. In all three irrigation areas (Dongola, Wad Medani and New Halfa), regression analysis detected upward trends in the growing-season temperature. The yields were negatively correlated with the growing-season temperature, particularly the frequency of days with minimum temperature above 20 °C in Northern State, maximum temperature in Gezira State, and minimum temperature in Kassala State. These results confirm that the recent increase in the growing-season temperature might have reduced the yield to some extent in Sudan.

Downscaling of rainfall data

Robust configurations of the Weather Research and Forecasting (WRF) model, especially cumulus parameterization schemes, for different climatic zones of Sudan were identified, focusing on wet season (June–September) rainfall, which is a determinant of summer crop yields. Downscaling experiments were carried out to compare the following schemes: Betts–Miller–Janjic (BMJ), improved Kain–Fritch (KFT), modified Tiedtke, and Grell–Freitas. Results revealed that BMJ performed better for wet season rainfall in the hyper-arid and arid zones; KFT performed better for rainfall in July and August in the semi-arid zone where most summer crops are cultivated. Specific cumulus parameterization schemes of the WRF model therefore need to be selected for specific climatic zones of Sudan.



スーダンにおけるダウンスケール実験の領域
The domain of the downscaling experiments in Sudan

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。また、ダスト研究の他に、(4) 乾燥地 × 温暖化プロジェクトを推進している。本年度は主に以下のことを実施した。

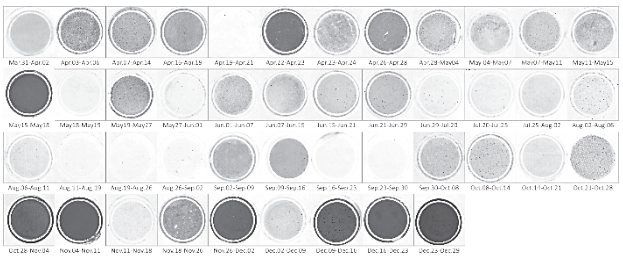
課題 (1) では、気象台データと MODIS 衛星画像を用いた東アジア準リアルタイムダストモニタリングシステムの維持更新を行ってきたが、元データとして利用していた MODIS Rapid Response System のサービスが終了したため、ひまわり 8 号画像等（気象庁 HP）で代用した。

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及び昨年度実施した Gantsetseg 氏 (IRIMHE) に依頼した現地観測のいずれも実施できなかった。しかし、現地住民に依頼している植生調査は実施できた。Buyantogtokh 氏（D3, 連合農学研究科）のレキ調査結果、Wu Jing 氏（特命助教）の枯れ草調査結果を既存 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。レキ広域データについては気象研究所との共同研究により気象研究所開発の数値モデル NHM-Chem-Dust に組み込んだ数値実験を開始した。

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。別途、JST ジュニアドクター育成塾・探究コースにおいて、乾性・湿性沈着の観測を行った。

課題 (4) では、気候変動とその草原生態系への影響（モンゴル）及びコムギ生産への影響（スーダン）の研究を進めた。

これらは、環境研究総合推進費（課題番号 JPERF20205001）、乾燥地 × 温暖化プロジェクト、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。



A seasonal variation of color and density of dry- and wet-deposited substances, which is collected on the roof of ALRC from April to December in 2020.

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. In addition, (4) Project Impacts of Climate Change on Drylands (ICC×DRYLANDS) is promoted. Major works in the fiscal year are described as below.

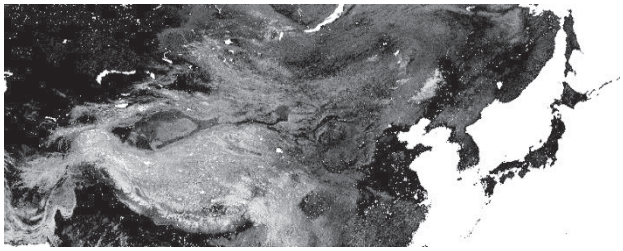
On the subject (1), the near-real time East Asia dust monitoring system using MODIS satellite images has been operated for long time. However, the service of MODIS Rapid Response System was over. Therefore, I substitute images from it with images of Himawari-8 satellite (JMA HP).

On the subject (2), due to COVID-19, I could not conduct either on-site observations by ourselves or our requested ones by Ms. Gantsetseg (IRIMHE), which could be done in the previous fiscal year. However, I could carry out vegetation surveys by residents in our site. I made test datasets of stone and dead leave for wide area by applying past field observation results by Mr. Buyantogtokh (D3, the United Graduate School of Agricultural Sciences) and Dr. Wu Jing (Assist. Prof.). Regarding to stone, numerical experiments incorporating the data into NHM-Chem-Dust, which is a numerical model developed by the Meteorological Research Institute (MRI), started in a collaboration with MRI.

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.). In addition, I conducted samplings of dry- and wet-deposited substances under the exploration course of JST Junior Doctor Program.

On the subject (4), researches of climate change and its effect on grassland ecosystems in Mongolia and its effect on wheat production in Sudan were proceeded.

These works were supported by the Environment Research and Technology Development Fund (JPMEERF20205001), by Project ICC×DRYLANDS, by International Platform for Dryland Research and Education (IPDRE), and by ALRC joint researches.



A test dataset of stone distribution in East Asia using a result of Buyantogtokh et al. (2021).

小林　伸行（国際開発協力学）

畜産：

乾燥地の開発においては、自然環境の保全と住民の生計向上・生活改善とのバランスのとれた総合的・持続的な開発が重要であるとの認識に立ち、畜産による土地利用とこれによる自然環境とのバランスある発展につき、各地域で適応可能な策の提示を目指す。

これに関し、JICA/JST 科学技術協力事業「次世代型・持続可能な土地管理フレームワークの開発」において、エチオピア・青ナイル上流域の 3 小流域を対象に、過放牧による草地の劣化防止と効率的な家畜生産を図るべく、舎飼いでの適切な飼料設計のための試験を継続してきた。

同国で一般的なフォガラ種乳牛による飼養試験（2019 年度）では、舎飼い飼養に適した草種（ネピアグラス）の供与が、放牧を伴う慣行法と比べて優れた乾物摂取量・乳量とメタン発生量の低下を示した。これを受け、高泌乳量への期待から同国での導入が進められているホルスタイン種交雑牛に対しても同様の飼養試験を実施した（～2021 年 12 月）。今後、結果の分析を行ない、放牧に代わる舎飼いでの適切な飼料給与法の構築を進める。

国際協力：

乾燥地技術の適用現場の多くが途上国にあることから、その普及のため、これら国々への国際協力を行なう。国際乾燥地研究教育機構によるフィリピン「生活の質改善を目指した糖尿病予防プロジェクト」において、患者リーダー及び地域保健師（同国パテロス町）による糖尿病自己管理のための普及啓発活動への支援を継続した。

同活動の成果を把握するための患者向け集団健診の実施が、新型コロナウイルス感染への懸念から中断しているため、活動に携わる共同研究者（現地関係者）および一部患者との間でオンラインによる定期協議を行ない、健診を再開できるまでの間、可能な対応策を助言している。

また、これまでの活動に対する現地関係者の意見や今後の活動への期待を動画にとりまとめ、本学医学部学生に対する教材として活用（授業の中で紹介）した。さらに、活動を通じた現地関係者の意識の変化を既収集データから分析し、活動の持続性向上のための知見を得た。

Cow crossbred with Holstein-Friesian used for feeding trials in 2021 (in Zenzerma Campus of Bahir Dar University, Ethiopia)

Kobayashi Nobuyuki (Associate Prof., International Development Cooperation)

Livestock:

Recognizing that comprehensive/sustainable development with environmental conservation and farmers' livelihood improvement is important especially in drylands, we aim to propose applicable measures to achieve both land utilization and environmental conservation with livestock raising.

Therefore, for 'the Project for development of sustainable land management framework' funded by JICA/JST in Ethiopia, we tried to improve feeding design for indoor-fed beef/dairy cattle to prevent the degradation of pasture land due to overgrazing and to achieve effective animal production in the 3 watersheds of Upper Blue Nile basin.

Through feeding trials using Fogera dairy cows, a popular breed of Ethiopian dairy cows, provision of a promising grass species (Napier grass) improved feed intake, milk yield, and reduced CH_4 emissions, compared with traditional feeding with grazing cows.

In 2021, we carried out the similar feeding trials by using the crossbred cows with Holstein-Friesian, which is expected to achieve higher milk yield. We will analyze the collected data, and try to establish the appropriate indoor feeding for dairy cows in Ethiopia.

International Cooperation:

Most technologies for drylands are applied in developing countries. Activities for development in these countries are important. Through 'the Project for enhancing the preventive measures for diabetes in Philippines', we supported extending education for the patients' diabetes self-management by their leaders and the local health professionals. In 2021, because the medical check-ups to monitor effects of the extension works have been suspended due to the risk of COVID-19 infection, we supported them by advising possible measures to be taken through on-line meeting. Furthermore, we produced a short movie of the leaders' and patients' opinions expectation for the Project and used it as practical lessons in the lectures for medical students in Tottori University. We also analyzed the changes of leaders' cognition and emotions through their extension activities, and obtained useful insights to enhance the sustainability of the activities.

Introduction of the project to enhance preventive measures for diabetes in Philippines through lectures for medical students of Tottori University

Zerihun Nigussie Gebresilasie (Specially-Appointed Assist. Prof., Socio-economics of Sustainable Land Management)

The Sustainable Land Management Socio-economics Subdivision undertakes research mainly as follows:

(1) To understand the mechanisms behind the widespread application of few sustainable land management practices by small-scale farmers while significant others still lagging behind,
(2) To examine small-scale farmers' livelihoods, livelihood diversification and its probable link with sustainable land management,
(3) To clarify mechanisms to enhance participation of resource-constrained farmers (landless youth and women) in sustainable land management through engaging them income generating activities, and
(4) To understand ways to engage local stakeholders into continual experiential learning for sustainable watershed management.

These research activities have been continuing under the support of the project "Development of Next Generation Sustainable Land Management Framework to Combat Desertification-SATREPS", Grant Number JPMJSA1601, funded by JST/JICA.

In this fiscal year, I have obtained the following results:

1. The production of value-added products from locally accessible and underutilized biomass residues is a potential to expand Ethiopia's supply of renewable energy. Expansion of tree-based plantation systems, in particular, might supply biomass residues for the production of better bioenergy products. The purpose of this research was to analyze producers' interest in providing biomass residues to a hypothetical biomass feedstock market. The data for this research came from a survey of 240 farmers. Although most farmers were unaware of possible biomass products, the majority reported an interest in providing biomass residues; nevertheless, the amount of interest varied depending on specific individual socioeconomic and demographic variables. Households with an enhanced biomass stove, greater land holdings, and higher income levels, for example, were shown to be more interested in participating in the hypothetical biomass market. Furthermore, bigger families and those who felt less exposed to firewood shortages reported greater interest. Overall, the findings suggest that farmers, especially those with younger and female heads of families, should be assisted via initiatives designed to assure their involvement in biomass supply chains. Respondents favored farm-gate sales of biomass, therefore collecting, baling, and shipping woody wastes must be effectively motivated, or new players must be brought into the supply chain. Providing energy-efficient equipment to homes, such as better stoves, would not only raise demand for biomass products, but it would also increase the quantity of biomass residues that could be given to the market rather than utilized at home.
2. Land degradation is the principal issue impacting the livelihoods of rural people in general, and resource-constrained farmers (e.g., landless youth and women) in particular. The majority of households rely on agriculture-based income, which is primarily reliant on the exploitation of limited natural resources. Furthermore, unless non-agricultural sectors of the economy can absorb excess rural labor, the rapidly growing population is shifting agricultural activities (crop cultivation and livestock grazing) to marginal and fragile lands, contributing to increased land degradation, low productivity, and increased poverty and social disparity. As a consequence, impoverished rural people are ill-equipped to adapt effectively to the environmental and livelihood shocks and pressures to which they are constantly subjected (e.g., shortage of land, lack of income, restricted possibilities). Land degradation happens owing to people's incapacity to access the resources that would enable them to derive their livelihoods in an ecologically sustainable fashion, and its impact is disproportionately larger for rural poor people (especially women and youth). As a result, my hypothesis states, "poor farmers' participation in inclusive agricultural business models that generate broad-based social, environmental, and economic effects (e.g., economic opportunities, education, social & economic cooperation, sustainable land management, value chain participation) would allow them to reduce poverty and social disparity while also protecting and restoring the environment on which they rely." Small-scale improved dairy production (i.e., promotion of improved dairy production system through improving genetic potential of local cows through crossbreeding; improving feed, feeding, and health management; promoting improved forage development and using manure for forage and vegetable production) and enabling farmers to establish saving and credit self-help groups to alleviate liquidity problems are currently underway in the Aba Gerima watershed (Figure 1). So far, the following results have been achieved as a result of these activities: (i) Household incomes increased by about 40%, and children's milk intake increased, improving their nutrition; (ii) Over 200 farmers engaged in backyard improved forage development activities; (iii) Over 90 farmers received crossbreeding bull services; and (iv) Farmers established a milk cooperative, which is now supplying milk to the Bahir Dar market.

Figure 1. Partial view of SATREPS Ethiopia project activities: (a) Crossbreeding bull introduced (b) Project beneficiaries collecting savings, (c) Monitoring farmer cows management and body conditions, (c) Farmers supplying milk to their milk cooperative.

Ayele A. Fenta (Specially Appointed Assistant Professor, Integrated Desertification Control)

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

(1) Development of an integrated framework to evaluate impacts of land use and management (LUM) alternatives on ecosystem services.

A general conceptual framework for analyzing the impacts of LUM alternatives on ecosystem services is shown below. The framework comprises six main components: (i) land use problem identification and objective setting, (ii) identification of best performing land-use-based solutions, (iii) formulation of LUM alternatives and modeling of key indicators, (iv) cost-benefit analysis, (v) evaluation of the LUM alternatives through stakeholders' workshop, and (vi) communicate the LUM alternatives to relevant stakeholders for institutional and financial support for implementation.

We demonstrated this approach using case studies of Aba Gerima and Guder watersheds in the Upper Blue Nile basin in Ethiopia. This study builds on extensive plot- and watershed-scale observations under conventional and improved land management practices to analyze the changes in runoff, soil loss, soil organic carbon (SOC) stock, and land productivity for five LUM alternatives compared to the baseline.

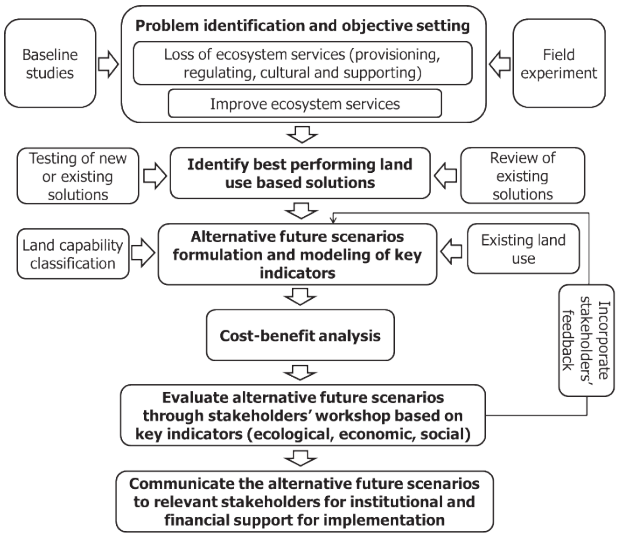
The best performing sustainable land management (SLM) practices were selected to formulate the land management options: soil bund integrated with grass, application of Polyacrylamide (PAM) combined with lime, and improved agronomic practices of reduced tillage and row planting for cropland; exclosure for grassland; exclosure integrated with trench for bushland; Napier grass and Desmodium uncinatum for improved forage.

Five LUM alternatives formulated for Aba Gerima and Guder watersheds are as defined below:

• Baseline – Current land use and existing conventional farmers' practices;

• Scenario I – Current land use plus SLM practices;

• Scenario II – No crop cultivation on steep slopes (>30%) plus SLM practices;



Integrated framework to evaluate the impacts of land use and management alternatives on ecosystem services.

• Scenario III – Khat/Acacia plantation on suitable areas plus SLM practices;

• Scenario IV – Forage production on suitable areas plus SLM practices; and

• Scenario V – Reforestation on degraded bushland and on hilly croplands plus SLM practices.

For the Aba Gerima watershed, results showed that the LUM alternatives can reduce runoff and soil loss by 11–71% and 66–95%; whereas SOC stock and watershed-scale gross land productivity could be improved by 36–104% and 48–134%, respectively compared to the baseline. Improved forage production on suitable areas and implementation of selected SLM practices on cropland and degraded bushland was the best performing scenario to reduce runoff (by 71%) and soil loss (by 95%); whereas Khat cultivation performed best to improve gross land productivity (by 134%) followed by improved forage production (by 91%).

For the Guder watershed, the alternative future scenarios can reduce runoff and soil loss by 71–95% and 75–96%; whereas SOC stock and watershed-scale gross land productivity could be improved by 2–51% and 49–83%, respectively compared to the baseline. Among, the alternative scenarios, Scenario-IV (improved forage production) was the best performing scenario to reduce runoff and soil loss (by about 95%) and to improve gross land productivity (by 83%).

Reforestation on degraded bushland and on hilly cropland and implementation of SLM practices on cropland resulted in the highest SOC stock improvement in Aba Gerima and Guder watersheds.

The results of cost-benefit analysis showed that the LUM alternatives were economically more profitable compared to the baseline. The stakeholders' evaluation of the LUM alternatives appeared to be divergent. Implementation of SLM practices on current land use (Scenario-I) and acacia plantation (Scenario-III) followed by the pro-forage production (Scenario-IV) were the first two priorities of the land users in Aba Gerima and Guder, respectively. Khat production (Scenario-III) was not a priority choice of the experts and land users despite its high economic and ecological benefits. This is mainly because Khat cultivation is not sustainable for the following reasons: (i) high water demand that led to conflict among neighbouring farmers, (ii) high labour requirement, (iii) high input requirement (chemicals to control disease affecting Khat), (iv) Khat's volatile market price, government's policy isn't in favour of Khat production.

Stakeholders' evaluation of the LUM alternatives based on analytic hierrarchy process.

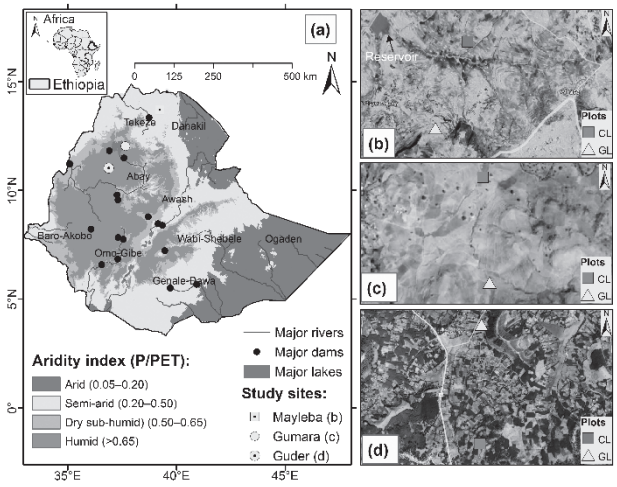
	Land	Policy	Researchers			
Aba Gerima	users	makers	Social	NRM	Crop	Livestock
Scenario-I	**0.34**	0.12	0.22	0.11	0.11	0.06
Scenario-II	0.07	0.15	0.15	0.13	0.13	0.17
Scenario-III	0.09	0.05	0.09	0.12	0.21	0.06
Scenario-IV	0.31	0.32	**0.32**	0.30	**0.34**	**0.40**
Scenario-V	0.18	**0.37**	0.21	**0.34**	0.21	0.30
Guder						
Scenario-I	0.20	0.17	0.22	0.14	0.19	0.17
Scenario-II	0.10	**0.29**	0.15	0.16	0.18	0.16
Scenario-III	**0.33**	0.12	**0.24**	0.21	0.17	0.18
Scenario-IV	0.22	0.19	0.18	0.16	**0.24**	**0.34**
Scenario-V	0.15	0.23	0.21	**0.33**	0.22	0.15

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

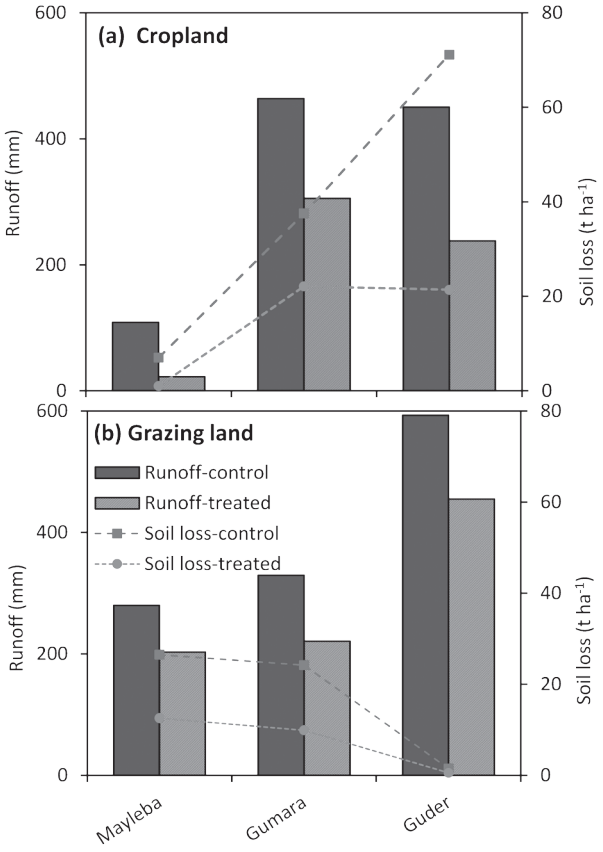
The soil erosion and conservation subdivision of the SATREPS-Ethiopia project conducts research on development of low cost and accurate soil erosion prevention methods for cultivated and non-cultivated lands in the Ethiopian highlands.

In the fiscal year 2021, I analyzed "runoff and soil loss response from cropland (CL) and grazing land (GL) in three contrasting climatic environments of Ethiopia: Mayleba (semi-arid), Gumara (dry sub-humid), and Guder (humid). The analysis was made using runoff and corresponding sediment concentration data collected from plots of CL and GL with (treated) and without (control) soil and water conservation (SWC) measures (trenches, stone/soil bunds with trenches, and exclosure). Statistical analysis was performed to evaluate the significance of differences in runoff and soil loss values across different environments, land use types and SWC measures.

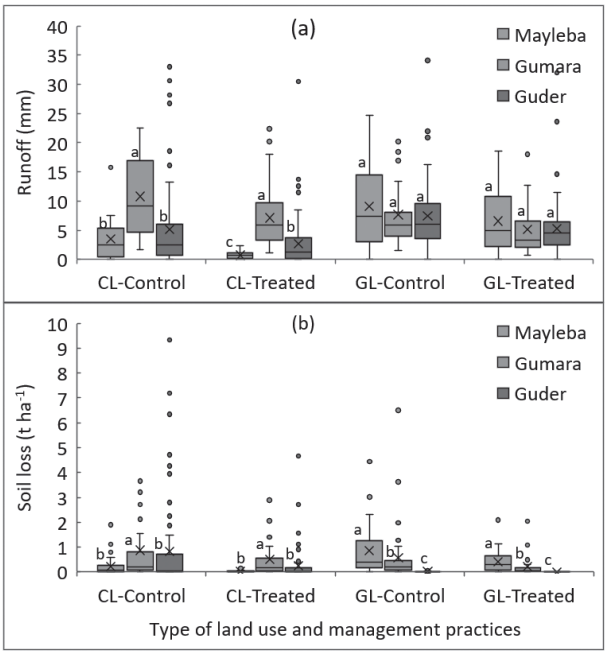
The results revealed substantially variation in runoff and soil amounts across land use types, SWC measures, and climatic environments. In control plots at semi-arid site, seasonal runoff and soil loss were far higher from GL (280 mm, 26.5 t ha^{-1}) than from CL (109 mm, 7.0 t ha^{-1}). In contrast, in control plots at dry-subhumid site, they were higher from CL (464 mm, 37.5 t ha^{-1}) than from GL (330 mm, 24.2 t ha^{-1}), and at humid site, soil loss was higher from CL (71.2 t ha^{-1}) than from GL (1.5 t ha^{-1}). The higher amounts of both runoff and soil loss from GL at the semi-arid site were attributed to a lack of protective vegetation cover and soil compaction due to intense grazing. At the dry sub-humid and humid sites, higher soil loss amounts in CL can be linked to excessive tillage operations. Although SWC measures substantially reduced seasonal runoff depth and soil loss relative to control plots, soil loss from GL with trenches at the semi-arid site (12.6 t ha^{-1}); CL with soil bunds and trenches at dry sub-humid (22.1 t ha^{-1}), and humid (21.4 t ha^{-1}) sites remained higher than the average tolerable soil loss rate (10 t ha^{-1} year^{-1}) for the Ethiopian highlands. Thus, the results of this study will help plan suitable SWC measures in regions, including drylands, where biophysical features and human activities vary with space and time, as they do in Ethiopia.



Location of the study sites displayed on an aridity index (AI = P/PET; P = annual rainfall depth; PET = annual potential evapotranspiration depth) map of Ethiopia (a) and location of experimental plots on cropland (CL) and grazing land (GL) at the Mayleba (b), Gumara (c), and Guder (d) sites.



Seasonal runoff and soil loss amounts for control and treated plots in cropland (a) and grazing land (b) at Mayleba, Gumara and Guder sites, representing the semi-arid, dry sub-humid and humid climatic environments of Ethiopia, respectively.



Daily runoff depth (a) and soil loss (b) during the rainy season in control and treated plots of cropland (CL) and grazing land (GL) at Mayleba, Gumara, and Guder. In each treatment type (control and treated), boxes labelled with different letters indicate that the median values differ significantly across study sites (Mann–Whitney *U*-test, $P < 0.05$).

濱本　亨（環境土壌生態学）

環境土壌生態学分野では以下のような研究を行っている。

(1) 将来気候変動に伴う土壌炭素・窒素循環、および農業生産性の影響

(2) 劣悪土壌環境下で創られる、土壌微生物多様性の解明

(3) 作物の遺伝的多様性と土壌微生物多様性との関連解明

これらの研究は、日本学術振興会による科学研究費 (課題番号 18J10924) などの援助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. 気温上昇や大気中 CO_2 濃度増加は、微生物活動を刺激し、有機物分解が加速される。土壌劣化やさらなる気候変動の原因となる。そのため、長期的な環境変動に対する適応策と同時に、気候変動に対する緩和策を一体的に進めることが極めて重要である。本年度は、気候変動によって改変した土壌、および微生物環境における作物生育に着目した実験を進めた。
2. 砂丘生態系などの貧栄養な低炭素土壌では、土壌中からの養分獲得も限定的であり、植物に必要な水や窒素などの獲得が極めて難しい。そのような劣悪な環境にも耐えうる植物を中心とした植物群落を形成しており、独特で貴重な生態系である。特に栄養状態に制限がある土壌環境に棲む微生物群集は、地上部とのより強い繋がりによって維持・形成されていると考えられるが、その実態は未だ明らかでない。本年度は、砂質土壌の微生物多様性の調査を進めた。
3. 劣悪な土壌環境下でも生育できる作物（ササゲ､パールミレット、テフなど）の遺伝的多様性・未利用資源などが大きく注目され、その理解が進んでいる。また、ササゲなどのマメ科植物は、特定の細菌と共生し根粒を形成することにより、窒素固定を行う。本年度は、複数系統のササゲを栽培し、それらと共生している根粒菌の予備的調査を進めた。

Toru Hamamoto (Specially appointed Assistant Professor, Environmental and Soil Ecology)

The Environmental and Soil Ecology Subdivision conducts research mainly as follows:

(1) Effects of soil carbon / nitrogen dynamics and agricultural productivity under future climate conditions

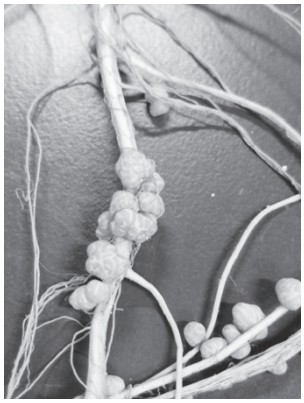
(2) The microbial diversity in infertile soils

(3) The relationship between crop genetic diversity and soil microbial diversity

These studies are conducting under the aid by Japan Society of the Promotion of Science Grants (KAKENHI 18J10924).

In this fiscal year, I obtained results from following research topics:

1. Future climates, which are under elevated CO2 concentrations and elevated temperature, stimulate microbial activity and hence accelerate organic matter decomposition. It is important to integrate adaptation and mitigation against climate change. This year's experiment focused on the effects of crop growth on future climate soil conditions, which interacted with the carbon and nitrogen cycle.
2. In soils with limited nutrients, such as sand dune ecosystems, it makes extremely difficult for plant growth. Such ecosystems are unique and valuable, but vulnerable. In particular, soil microbial communities in limited soil nutrient status could be maintained and formed by significant influences with above-ground parts, but it is still unknown how above- and below-ground ecosystems interacts. This year, we proceeded with a survey of microbial diversity and community structures in sandy soils.
3. The genetic diversity of crops which can grow even in poor soil environments (cowpea, pearl millet, and teff) have attracted much attention, and their understanding is promoting. In addition, legume crops such as cowpea fix nitrogen by forming nodules in symbiosis with specific bacteria. This year, we cultivated different types of cowpeas and conducted a preliminary experiment of in rhizosphere.



Cowpea root nodules

A pot experiment simulated future climate conditions

Jing Wu (Specially Appointed Assist. Prof., Wind Erosion Climatology)

The wind erosion climatological subdivision conducts research mainly on improvement of dust prediction accuracy through applying land surface effects on dust emission in arid and semi-arid regions.

In this fiscal year, I investigated spatial and temporal variations of dust occurrence and three definitions of strong wind frequency over Gobi Desert and surrounding regions in March and April, months when dust occurrence is frequent, during 2001–2021. I evaluated the effects of variations in dry vegetation on dust occurrence by using the threat scores of forecasted dust occurrences for each strong wind definition. The results are as follows:

1. Spatiotemporal variations in dust occurrence and wind conditions

In all regions except grasslands in Inner Mongolia, the dust occurrence frequency (DOF) was greater in April than in March (Fig. 1a–b). High DOF values during 2001–2021 were found in the Gobi Desert in southern Mongolia. The highest DOF value was observed at Tsogt-Ovoo, which has previously been observed to be a dust source hotspot.

The average DOF over the study region was also higher in April (3.39±1.95%) than in March (2.61±1.51%) (Fig. 1c–d), consistent with previous studies. The DOFs generally declined from 2001 to 2021, especially in April.

We defined threshold wind speed in three ways: as a spatiotemporally constant value (6.5 m s^{-1}, often employed in dust models, hereinafter, $u_{6.5}$); as a value statistically estimated from surface synoptic observations, which is interannually constant but spatially variable (hereinafter, $u_{t5\%}$); and as a value estimated by using both synoptic data and the dry vegetation coverage estimated from the MODIS Soil Tillage Index (STI), which is spatiotemporally variable (hereinafter,$u_{t(STI)}$). Strong wind is defined as wind speeds exceeding the threshold wind speed for dust occurrence. Temporal changes in the average strong wind frequency (SWF) calculated using the first definition for threshold wind speed ($SWF_{u_{6.5}}$) ranged from 10% to about 40%, but $SWF_{u_{t5\%}}$) and $SWF_{u_{t(STI)}}$) values, calculated using the second and third definitions, respectively, were always lower than 20% (Fig. 1c–d). $SWF_{u_{6.5}}$ was obviously larger than both $SWF_{u_{t5\%}}$ and $SWF_{u_{t(STI)}}$; therefore, both $u_{t5\%}$ and $u_{t(STI)}$) were higher than 6.5 m s^{-1}.

2. Effect of dry vegetation coverage on dust occurrence variation

Dust occurrence is predicted when wind speed exceeds the threshold wind speed. To evaluate the dust prediction accuracy, we used the threat score (TS). The TS, which ranges between 0 and 1, is the ratio of the number of correctly predicted events to the total number of events minus the number of correct rejections. We defined TS in three ways ($TS_{u_{6.5}}$, $TS_{u_{t5\%}}$, and $TS_{u_{t(STI)}}$), which were calculated from the number of predicted dust occurrence events obtained by using the three definitions of threshold wind speed.

In March, Threat scores increased from $TS_{u_{6.5}}$ to $TS_{u_{t5\%}}$ throughout the study region except at two stations (Tsogt-Ovoo in Mongolia and Ejin-Qi in Inner Mongolia) (Fig. 2a). However, increases from $TS_{u_{t5\%}}$ to $TS_{u_{t(STI}}$ were smaller at 13 observatories, and decreases were found at 10 stations (Fig. 2b). This result indicates that in addition to the dry vegetation coverage, other factors such as snow cover and soil temperature should be considered to explain the variations in dust occurrence.

In April, increases from $TS_{u_{6.5}}$ to $TS_{u_{t(STI)}}$ (Fig. 2c) and from $TS_{u_{t5\%}}$ to $TS_{u_{t(STI)}}$ (Fig. 2d) occurred at almost all stations. Moreover, increases at stations in the Inner Mongolian grasslands were larger. These results suggest that the variation of dry vegetation coverage is the crucial factor in dust occurrence in April through its strong influence on the threshold wind speed. Therefore, we propose that the dry vegetation coverage is a key factor controlling dust occurrence variations in April. The findings imply that estimation of dry vegetation coverage should be applied to dust models.

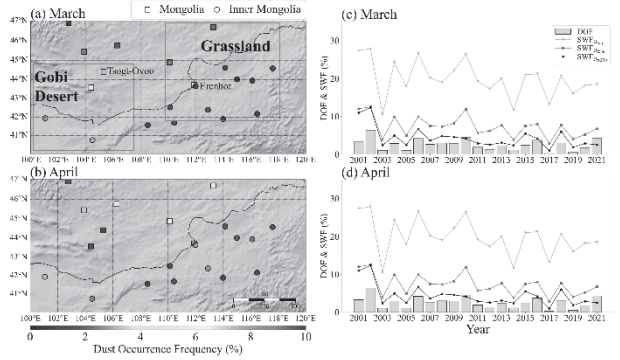


Fig. 1 Spatial distribution of the average dust occurrence frequency at SYNOP observatories in Mongolia (squares) and Inner Mongolia (circles) in (a) March and (b) April during 2001–2021. The line shows the border between Mongolia (to the north) and Inner Mongolia, and the red boxes in (a) indicate the Gobi Desert and grasslands areas. Temporal variations of the average dust occurrence frequency (DOF; gray bars) and strong wind frequencies ($SWF_{u_{6.5}}$, triangles; $SWF_{u_{t5\%}}$, squares; and $SWF_{u_{t(STI)}}$, circles) over the study region in (c) March and (d) April during 2001–2021.

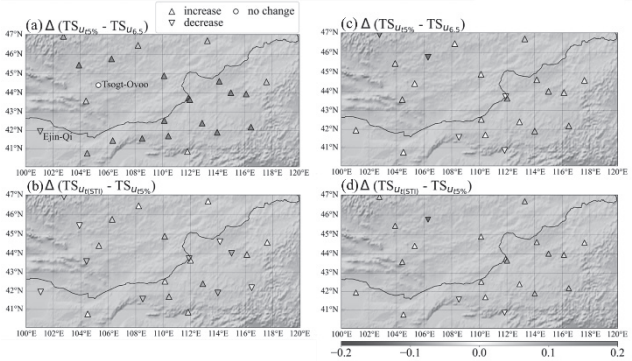


Fig. 2 Increases and decreases between (a) $TS_{u_{6.5}}$ and $TS_{u_{t5\%}}$, and (b) $TS_{u_{t5\%}}$ and $TS_{u_{t(STI)}}$ in March, (c) $TS_{u_{6.5}}$ and $TS_{u_{t5\%}}$, and (d) $TS_{u_{t5\%}}$ and $TS_{u_{t(STI)}}$ in April are shown by triangles and inverted triangles, respectively, and the color indicates the magnitude of the change.

2）環境保全部門

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、中国、モンゴル等の研究機関、および国内の大学・研究機関との共同研究で行っている。本年度は、新型コロナの影響で海外調査はできなかったが、オンラインで海外共同研究者との研究を継続した。

1. 2022 年 3 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、モンゴル農業科学アカデミーのガンボルド博士、そしてモンゴル食料・農業・軽工業省のジャンバルツェレン氏とともに、モンゴルの放牧地管理に関する 3 種の書籍を出版した。本書は持続可能な放牧地管理を目指してモンゴル生命科学大学と共同で行ってきた研究成果の 1 つである。本書は、完全モンゴル語によるものであり、モンゴルの放牧地管理者や牧畜民に広く使ってもらうことを目的としている。出版にはモンゴル政府 (MINISTRY OF FOOD, AGRICULTURE AND LIGHT INDUSTRY, MONGOLIA) や鳥取大学国際乾燥地研究機構の支援も頂いた。

2. 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)『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』が採択され、6 月にキックオフ・ワークショップをオンラインで開催した。しかし野外調査は新型コロナの影響で実現できなかった。

2) Environmental Conservation Division

Norikazu Yamanaka (Prof., Revegetation Science)

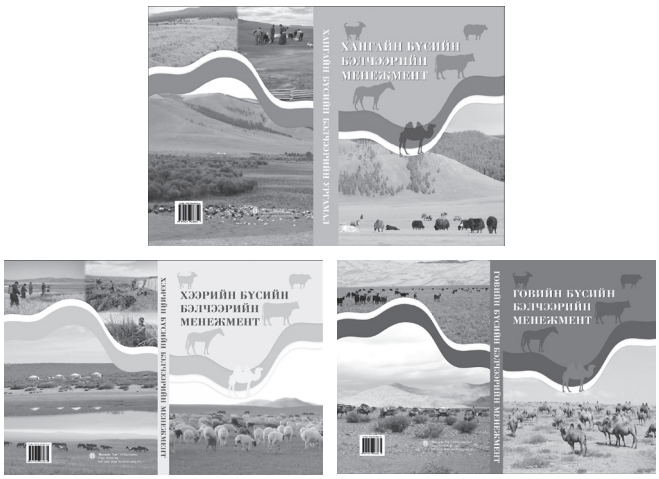
The Revegetation science subdivision conducts research on the revegetation in arid areas and ecosystem restoration of desertified lands based on plant ecology. Main research topics of revegetation science subdivision are as follows.

(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

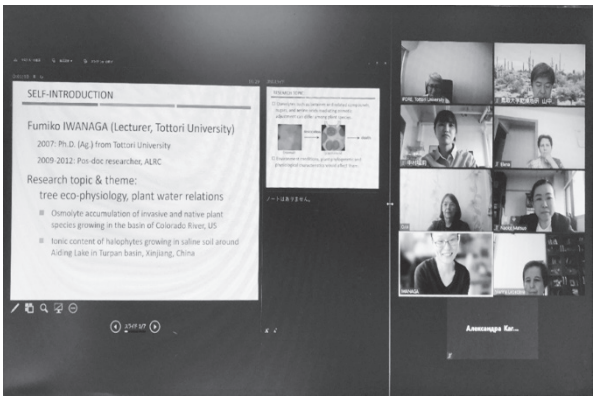
These researches are being conducted in overseas research institutions in China, Mongolia etc. and those in Japan. In this fiscal year, I was not able to conduct overseas research due to the Covid-19, but I continued research with overseas collaborators online.

1. In March 2022, together with Dr. Undarmaa (Mongolian University of Life Sciences), Dr. Ganbold (Member of Academy of Mongolian Agricultural Sciences) and Mr. Jambaltseren (Ministry of Food, Agriculture and Light Industry, Mongolia), we published three books on rangeland management with the support of the Mongolian government (MINISTRY OF FOOD, AGRICULTURE AND LIGHT INDUSTRY, MONGOLIA) and IPDRE of Tottori Univ. These books are one of the results of a joint research with the Mongolian University of Life Sciences aimed at sustainable rangeland management and aims to be widely used by Mongolian rangeland managers and pastoralists.

2. Research project entitled “Climate resilience and productivity of halophytes in Turanian-Eurasian Ecosystems" was selected as FY2021 Bilateral Joint Research Program between Japan (JSPS) and Russia (RFBR). A kick-off workshop was held online in June 2021. However, field surveys could not be conducted due to the Covid-19.



Rangeland Management of Khangai Region (upper), Rangeland Management of Steppe Region (left-lower) and Rangeland Management of Gobi Region.(right-lower) (March 2022)



Online kick-off workshop of the Japan (JSPS) - Russia (RFBR) Bilateral Joint Research Project (June 2021)

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、モンゴルにおける家畜の被食による生態系劣化とアーバスキュラー菌根菌との関係について解析を行い、論文投稿を行った。生態系の健全性を評価する指標として、植物の地上及び地下部乾燥重量や土壌養分を含んだ生態系の多機能性指標を用いた。結果として、この多機能性指標は家畜の被食強度に伴って低下すること、そして菌根菌の優占度と正の関係にあることが示された。このことは、適切な菌根菌の優占度管理がモンゴル草原の管理や修復に有効である可能性を示している。この成果は Ecological Indicators 誌に掲載された。

Livestock grazing (upper), healthy grassland (bottom left), and heavily grazed grassland (bottom right)

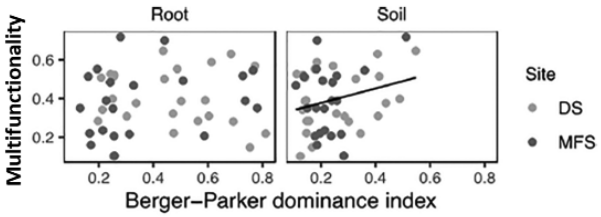
Takeshi Taniguchi (Assoc. Prof., Microbial Ecology)

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:

This year, we analyzed the relationship between arbuscular mycorrhizal fungi and ecosystem degradation due to livestock grazing in Mongolia. The ecosystem multifunctionality index, which includes above- and below-ground dry weight of plants and soil nutrients, was used as an index to evaluate ecosystem health, and it was shown that this index decreased with increasing in livestock grazing and was positively correlated with the prevalence of mycorrhizal fungi. The result indicates that increasing the prevalence of appropriate mycorrhizal fungi may lead to the maintenance or restoration of Mongolian grasslands. The results were published in a Journal, Ecological Indicators.



Relationship between ecosystem multifunctionality and dominance (Berger-Parker dominance index) of arbuscular mycorrhizal fungi

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) 乾燥地における熱フラックスの定量的解明
(2) 気象データとリモートセンシングデータを併用した地表面湿潤度のモニタリングとモデリング
(3) 北東アジアにおいて植生がダストの発生を抑制する物理的メカニズム

これらの研究は、日本学術振興会による科学研究費 (課題番号 19H04239、19K06116)、宇宙航空研究開発機構 (JAXA) の Global Change Observation Mission の援助 (ER2GCN122) 等により、主として中国やモンゴル、エジプトで行われた。以下に研究結果を示す。

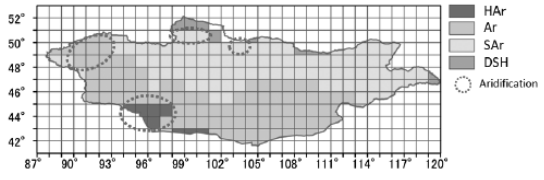
1.「衛星による観測の補完および面的モニタリング手法」

①近年のモンゴルにおける干ばつや土地劣化を対象に、本手法の実証試験を行った。2000 年から 2009 年にかけて、モンゴルでは干ばつが頻発しているが、本研究ではこの期間の干ばつの発生をモンゴルの北中部（草原）と南部（乾燥地域）の 2 つのゾーンに分け、衛星指標によってその要因を特定することを試みた (図参照)。その結果、この期間の降水量が減少トレンドであることにより、植生や地表面の湿潤度が減少していたことが示唆されたが、2009 年から 2020 年にかけては降水量の増加トレンドにより、植生や地表面の湿潤度が増加している傾向が明らかになった。本指標は土地の劣化のみならず、経年的な干ばつの状況を監視できることが示唆された。

②「風食的砂漠化の面的なモニタリング」に関し、東アジアを対象にした風食の数値シミュレーションを行い、風食が発生し始める臨界風速の影響について探った。その結果、発生源の違いや大気中のダスト濃度に与える臨界風速の影響は大きく、本計測システムの根幹に関わる物理量であることが示唆された。

2.「砂漠化監視に特化した計測システムの試作と開発」

「特許出願 (特願 2020-192786)」を行った飛砂計を用い、小型境界層風洞で実証試験を行った。本研究では、レキ砂漠や草原の環境を風洞に再現し、①レキ面上の風に対する抵抗は、被覆率が 15% で最高値に達し、20% 以上になると逆に減少、安定化する、② 4cm の高さを境に、空気の流れはそれぞれ慣性境界層と粗度境界層に分割される、③飛砂粒子が周囲の気流からエネルギーを吸収できる領域が慣性境界層と粗度境界層との間に存在し、飛砂による侵食を高める作用がある、④柔軟性のある植生の上部が家畜に食べられても、飛砂を捕捉する効果に対し影響が少ない等、レキや植生が地表面近くの空気の流れに対して与える影響を物理的に解明することができた。



Spatial distribution of aridity during 2001–2013 in Mongolia

Reiji Kimura (Assoc. Prof., Meteorology)

The Meteorology Subdivision conducts research mainly as follows:

(1) Quantitative analysis of heat fluxes in arid land.
(2) Monitoring and modeling of surface moisture by combining the meteorological and remote sensing data.
(3) To make clear the physical mechanism for preventing the dust outbreak by vegetation in northeast Asia.

These studies are conducting under the aid by Japan Society of the Promotion of Science Grants (KAKENHI 19H04239、19K06116), and JAXA Global Observation Mission (ER2GCN122), especially in China, Mongolia, and Egypt. I obtained results from following research:

1. “Supplement of observation and spatial monitoring using satellite data"

① From 2000 to 2009, droughts were frequent in Mongolia. In this study, the occurrence of droughts during this period was divided into two zones, that is, the north-central (steppe) and the southern part (arid regions) of Mongolia, and attempted to identify the reasons by satellite indices. The results suggest that the wetness of vegetation and land surface was decreasing due to the decreasing trend in precipitation during this period, however from 2009 to 2020, increasing trend of precipitation revealed increasing trend of increased wetness of vegetation and the land surface. The indices suggests that it can monitor not only land degradation, but also drought conditions over the annual base.

② Mathematical simulation demonstrate that better representation of threshold wind speed in climate models is necessary to improve estimates of the emissions and transport of Asian dust in arid regions of East Asia and better understand its roles in the Earth system.

2. “Development of an observation system dedicated in desertification monitoring"

Gravels can protect soil from wind erosion, however, there is little known about the effects of fine-grained gravel on aerodynamic characteristics of the near-surface airflow. The drag coefficient of the fine-grained gravel surface reached the maximum value at 15% coverage and then tended to stabilize at gravel coverage 20% and greater. At a height of 4 cm, near-surface airflow on gravel surfaces can be divided clearly into upper and lower sublayers, defined as the inertial and roughness sublayers, respectively. In addition, an energy-exchange region, where sand particles can absorb more energy from the surrounding airflow, was found between the roughness and inertial sublayers, enhancing the erosional state of wind-blown sand.

Clipping reduced the frontal area, but there was little decrease in sediment accumulation until all of the above-ground biomass had been removed. These results indicated that sediment trapping by a single plant was likely attributable to the sheltering effect created by the lower part of the above-ground plant body; the flexible upper portion of the plant body apparently contributed very little to sediment trapping.

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. 海岸砂丘生態系における炭素循環に関する研究
2. 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
3. 森林土壌におけるメタン吸収の空間変動の制御因子に関する研究

これらの研究は、それぞれ鳥取大学テニュアトラックプログラムおよび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、各研究に関して下記の通り取り組んだ。

1. 鳥取県の海岸砂丘において、携帯型自動開閉チャンバー観測システムを用いて海浜植物群落毎（コウボウムギ、ケカモノハシ、ハマゴウ、カワラヨモギ）に土壌から排出される CO_2（土壌呼吸）、CO_2 交換、光合成および生態系呼吸に関する定期観測を行った。土壌呼吸および各植物地上部を含む生態系呼吸は地下 30 cm における地温の季節変化に伴う上昇に対して指数関数的に増加する傾向を示した。一方で、2021 年 8 月は例年と比して相対的に降水量が多かったため、土壌呼吸および生態系呼吸と土壌水分との関係性は、地温と比して相対的に弱いものであった。
2. 国立環境研究所との共同研究として、東広島アラカシ林において土壌の温暖化操作および大型マルチ自動開閉チャンバーシステムを用いた土壌呼吸、微生物呼吸、メタンフラックスの連続観測を継続した。2021 年の観測では、2022 年と同様に土壌呼吸および微生物呼吸は季節変化に伴う地温の上昇に対して指数関数的に増加する傾向が見られた。一方で、夏季の降水量が例年と比べて多かったため、夏季の乾燥影響が強かった 2020 年と比して土壌呼吸や微生物呼吸と土壌水分の関係性は相対的に弱いものとなった。
3. 国立環境研究所との共同研究として、鳥取大学演習林（三朝の森、蒜山の森、伯耆の森）における合計 5 ヶ所の林分において、携帯型自動開閉チャンバー観測システムを用いて土壌メタンフラックスの観測を行った。蒜山のブナ人工林および伯耆のアカマツ林では土壌水分と土壌メタン吸収の間に負の相関が見られたため、土壌水分は土壌メタン吸収の空間変動の一部を説明しうる環境因子であることが示唆された。

Measurement for soil CH_4 flux in a beech forest site in Hiruzen

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

The Terrestrial carbon cycle subdivision mainly conducts the following studies.

1. Research related to the carbon cycle in a coastal dune ecosystem
2. Evaluation of the long-term influence of soil warming on the soil organic carbon decomposition and the soil methane (CH_4) absorption
3. Research related to the control factors for soil CH_4 absorption in forest ecosystems

These studies are supported by the Tenure Track Program of Tottori University, the Joint Research Program of Arid Land Research Center, Tottori University (03A2001), and the Environment Research and Technology Development Fund (2-2006) of the Environmental Restoration and Conservation Agency of Japan. In this fiscal year, I worked on the above-mentioned studies as follows.

1. Soil CO_2 efflux (soil respiration), CO_2 exchange, photosynthesis, and ecosystem respiration were measured by using a portable automated chamber measurement system in a coastal dune ecosystem. Soil respiration and ecosystem respiration were exponentially increased along with the seasonal soil temperature rise at the depth of 30 cm. On the other hand, due to the plenty of rainfall in summer, the relationship between soil moisture and respiration (soil respiration and ecosystem respiration) was relatively weak compared with the relationship between soil temperature and respiration.
2. Soil warming treatment and continuous monitoring for soil respiration, heterotrophic respiration, and soil CH_4 flux were continued in an evergreen broad-leaved forest in Higashi-Hiroshima, western Japan as a collaborative study with National Institute for Environmental Studies. Based on observation data in 2021, soil respiration and heterotrophic respiration were exponentially increased along with seasonal soil temperature rise. On the other hand, due to the plenty of rainfall in summer, the relationships between soil moisture and those soil CO_2 effluxes (soil respiration and heterotrophic respiration) were relatively weak compared with that in 2020 when drought stress was obvious in summer.
3. Soil CH_4 flux was measured by using a portable automated chamber measurement system in research forests that belong to Tottori university (Misasa, Hiruzen, and Hoki, 5 stands in total). Significant negative relationships between soil moisture and soil CH_4 absorption were confirmed in a beech forest in Hiruzen and a red pine forest in Hoki. Those results suggested that soil moisture could partly explain the spatial variation of soil CH_4 absorption in those forest ecosystems.

CO_2 flux measurement in a coastal dune ecosystem in Tottori

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

The Environmental Physics Subdivision conducts research mainly as follows:

(1) Developing a novel wind erosion detection device for wind-blown sand measurements.
(2) Use of UAV photogrammetry for monitoring topographic changes in the 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. To prevents those damages, it is important to quantify aerodynamic characteristics of wind-blown sand, especially the structural characteristics of blown-sand flux. However, it still remains difficulties in observations of blown-sand flux in the fields due to technical limitations of observation devices. Recently, some observation devices have been developed to measure variations of sand flux with changes in wind speeds. However, devices that can simultaneously measure blown-sand flux and wind direction have not been developed.

   I developed an original wind erosion detection device for wind-blown sand observation in both filed and wind tunnel experiments (Fig. 1). It consists of four parts: piezoelectric blown-sand meters, data record, axis of revolution, and vertical tail. It can simultaneously measure the structure of blown-sand flux (i.e., vertical profiles of blown-sand flux) and wind direction. The device is now on a patent pending (No. 2020-192786). The device is expected to be used in the wind erosion monitoring system in coastal sand dunes for preventing wind-blown sand problems.

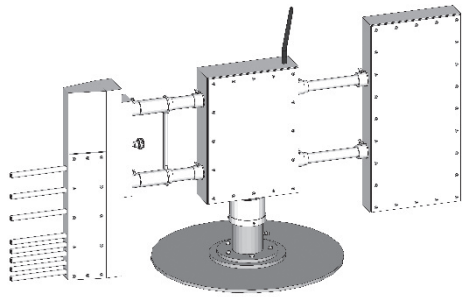


Fig. 1 Photo of the wind erosion detection device

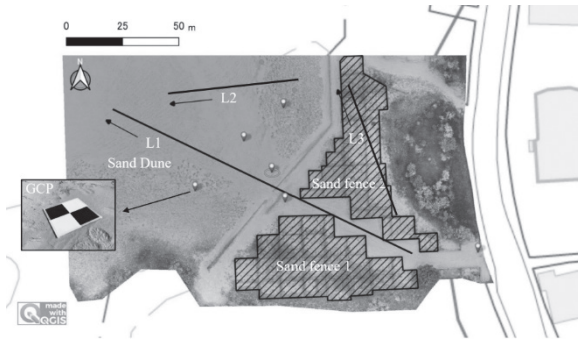


Fig. 2 Orthophoto of the study area based on images collected on May 13, 2021. Lines L1, L2, and L3 are the transects used to measure elevation profiles; the arrow direction indicates the direction of distance measurements.

2. The Tottori Sand Dunes, the largest area of natural sand dunes in Japan, is an important tourist attraction in the San'in Kaigan Geopark in western Japan. A sand fence has been emplaced to prevent blowing dune sand from damaging the environment and interfering with human activities; however, there has been no quantitative evaluation of its effectiveness. We collected imagery of the area around the sand fence (Fig. 2) from March to May 2021 with an unmanned aerial vehicle (UAV) and used the data to construct and analyze a time series of three-dimensional models via structure from motion (SfM) and multi view stereo (MVS) and geographic information system (GIS) techniques. We found that imagery collected on cloudy days and days when the sand surface had higher soil moisture yielded terrain models with superior accuracy. Moreover, after rectifying the UAV images using ground control points (GCP) and a total station, horizontal and vertical root mean squared errors were greatly improved to 0.018 ± 0.005 and 0.018 ± 0.007 m, respectively. We evaluated topographic and volumetric changes due to sand movement to and from the areas of sand fences by comparing successive elevation profiles of three cross sections of the study area (Figs. 3 and 4). The results show that UAV photogrammetry can be used to accurately monitor topographic changes and sand movements and provide a basis for planning mitigation measures such as wind-blown sand prevention.

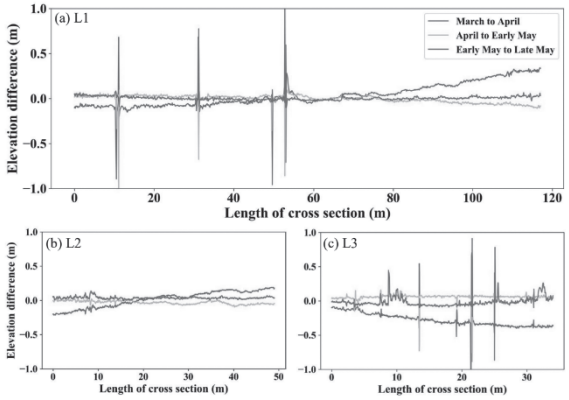


Fig. 3 Elevation changes on the three transect lines between March and April (blue), April and early May (yellow), and early May and late May (green).

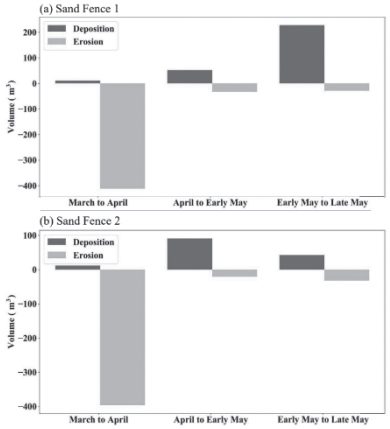


Fig. 4 Histograms showing volumetric changes within the two sand fence areas between March and April, April and early May, and early May and late May.

3) 農業生産部門

辻本　壽（分子育種学）

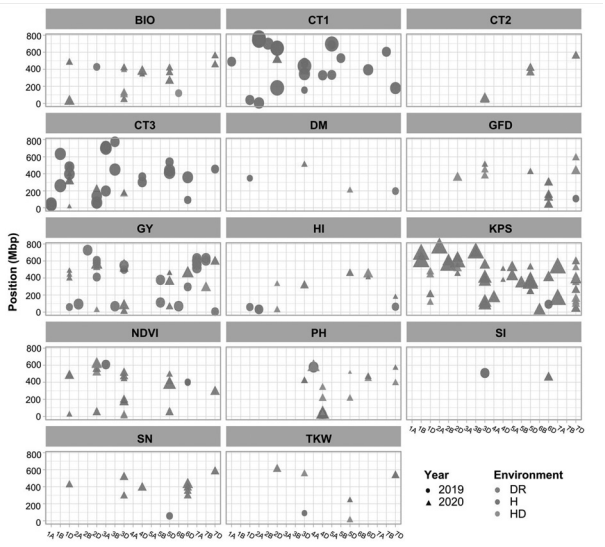
気候変動下で増加する人口のための食糧の生産は、人類にとって大きな課題である。不良な環境下でも生育できる作物品種の開発は、この問題に対する重要な解決策の一つである。私達は、コムギ近縁野生種の遺伝子プール内にストレス耐性を提供する遺伝子を探しており、その遺伝子を利用してストレス耐性コムギの品種を作り出そうとしている。

コムギ近縁野生種には、コムギが育つことができない乾燥、高温、塩害土壌など、非常に過酷な条件下で生育するものがある。したがって、これらの種は、ストレス耐性コムギ育種のための遺伝子を保有することが期待される。役立つ機能をもつ野生遺伝子を見出すためには、栽培種と野生種の形態学的および生態学的な差異を超えて正確にその性能を評価する必要がある。

私達は、種々の合成六倍体コムギとパンコムギ、野生2粒系コムギとマカロニコムギとの交配で、野生種の多様性を含む栽培コムギの系統群を開発した。これらの系統は、栽培コムギと形態が類似するが、野生種由来の様々な形質をもっている。

私達は、これら系統を多数のゲノムワイドマーカーでジェノタイピング（遺伝子型情報の取得）すると共に、スーダンの高温・乾燥環境において栽培し、フェノタイピング（表現型情報の取得）を行った。これらのデータを比較することにより、高温・乾燥環境に適応できる遺伝子領域を同定した。この遺伝情報を用いて育種選抜を確実にするための選抜マーカーを開発しようと考えている。

一方で、高温耐性の生理的機構を明らかにするために、乾燥や高温ストレスを受けた植物の応答を遺伝子発現や代謝物生産のプロファイルから調査した。その結果、これまで知られている適合溶質の蓄積以外に、耐性系統特異的に蓄積する化合物が見られた。この結果は、未だ解明されていない耐性機構の存在を示唆している。



Physical positions of markers associated with evaluated traits under heat (H) and combined heat-drought (HD) conditions and in the drought response under heat stress (DR). Itam et al. (2021) Theor. Appl. Genet. (2022) 135:337-350

3) Agricultural Production Division

Hisashi Tsujimoto (Prof., Molecular Breeding)

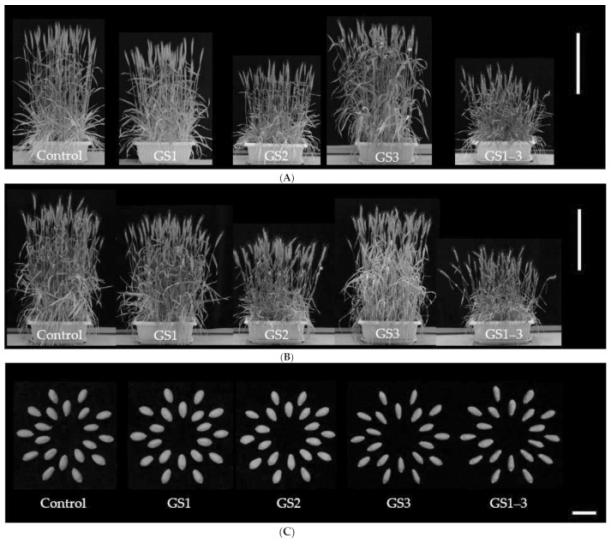
The production of food for a growing population under climate change is a major challenge for humanity. The development of crop varieties that can grow in poor conditions is one of the key solutions to this problem. We are looking for genes that provide stress tolerance within the gene pool of wheat related wild species and are trying to use those genes to create stress-tolerant wheat varieties.

Some wheat-related wild species can grow under very harsh conditions, such as dry, hot and saline soil where wheat cannot grow. Thus, these species are expected to carry genes for stress-tolerant wheat breeding. In order to find out the wild genes with useful function, we need to evaluate the performance correctly beyond the morphological and ecological difference between cultivated and wild species.

We developed derivatives of cultivated wheat including a diversity from wild species by crossing various synthetic hexaploid wheat with bread wheat and various wild tetraploid wheat with durum wheat.

We genotyped these lines with a number of genome-wide markers (to obtain genotypic information) and cultivated them in the hot and dry environment of Sudan for phenotyping (to obtain phenotypic information). By comparing these data, we have identified genetic regions that has a gene adaptable to hot and dry environment. We are trying to develop a selection markers to ensure breeding selection using this genetic information.

On the other hand, to elucidate the physiological mechanisms of high temperature and drought tolerance, we are investigating the response of plants to dry and heat stresses in terms of gene expression and metabolite production profiles. As a result, in addition to the known accumulation of compatible solutes, compounds that accumulate specifically in tolerant lines were found. This result suggests the existence of a resistance mechanism that has not yet been elucidated.



Effect of high temperature during each growth stage on plant and seed morphology. (A, B) Each plant at (A) anthesis and (B) 14 days post-anthesis (C) Harvested seeds. Bars: plants, 50 cm; seeds, 1 cm. Matsunaga et al. (2021) Int. J. Mol. Sci.,

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、新型コロナウィルスの感染流行により海外の現場に行けなかったため、主として国内において以下の研究に取り組んだ。

1. 限界地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ジャガイモとサツマイモとタマネギを供試作物とする灌漑実験を行った。
2. サンドポニックスおよび底面給水栽培システムの水管理および塩分管理に関する研究でメロンを供試作物とする灌漑実験を行った。
3. 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。乾燥地研究センター大型ガラス室内で 4 月から 7 月にかけて緑豆を供試作物として、また、9 月から 12 月にかけてジャガイモを供試作物として、さらに、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ソラマメを供試作物として行った。
4. 修士研究「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。

An irrigation experiment using potato in ALRC

An irrigation experiment using mungbean in ALRC

Haruyuki Fujimaki (Prof., Irrigation and Drainage)

The subdivision of irrigation and drainage in dryland studies on water-saving irrigation and salinity management associated with irrigation. Since we could not visit fields in abroad owing to the pandemic of COVID-19, following research activities were carried out in Japan:

1. Determination of irrigation depths using a numerical model and quantitative weather forecast as an activity of husbandry group under the “Project Marginal Land”. Irrigation experiments were carried out in the in ALRC using potato, sweet-potato, and onion.
2. Water and salinity management for a sand-ponics and an capillary-driven automatic irrigation system. Irrigation experiment using melon was carried out in ALRC.
3. etermination of leaching depth using a numerical simulation model of salt movement, funded by JSPS “Fostering Joint International Research (B)”. After carrying out a preliminary numerical experiment, we performed three field experiments in greenhouses using mungbean (April to July in ALRC), potato (September to January in ALRC) and Fababean (November to March in Ishigaki Island).
4. An experiment in ALRC as a master 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

An irrigation experiment using fababean 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の結果、塩生植物栽培実験の結果およびムウス沙漠植物実験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 との共同研究を推進し、結果および問題などについて検討した。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。

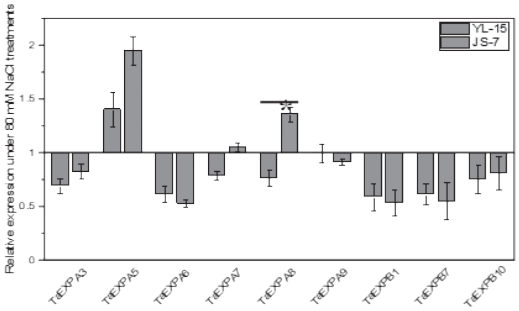
下の写真に研究成果および共同研究現地の様子を示した。

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 soybean, tomato, wheat and halophytes;
2. Relationship between root and plant salt 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 2021 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 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.



Relative expression of expansins in wheat cultivar YL-15 and JS-7 under salinity stress condition.

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 CENH3 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

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 と神戸大学の（松岡由浩）、スーダン ARC、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. JST の創発的研究支援事業に採択され、2021 年度より本格的に研究を開始しました。採択課題名は『染色体脱落の克服による遺伝資源概念の拡張』です。様々な環境に対応した作物を創りだすことは、非常に重要です。植物育種では、様々な変異を持つ親を交配し、両親よりも優れた子供を作り出す方法があります。一般的に、種を超えての交配は様々な形質を持つ子孫を作る事ができ、魅力的な方法です。しかし、遠縁の種を交配に用いた場合、雑種初期胚から片親の染色体が選択的に排除される、染色体脱落現象が報告されています（図 1)。本研究では、雌親にイネ科イチゴツナギ亜科に属するパンコムギとエンバクを用い、花粉親にイネ科キビ亜科に属する様々な *Pennisetum* 属植物を用います。パンコムギ、エンバクは世界中で食されている重要な作物です。しかし、乾燥、高温などの様々なストレスに弱いです。一方、トウジンビエ (Pearl millet: パールミレット) などが属する *Pennisetum* 属植物は乾燥、高温などに非常に強いです。多様性を持つ花粉親が染色体脱落へ及ぼす影響を網羅的に解明し、染色体脱落克服への突破口を見つけ出します。
2. 東京都立大学の岡本龍史教授との共同研究により、イネとコムギの卵細胞と精細胞を顕微授精法により融合させることにより、世界で初めてイネとコムギの亜科間での雑種植物作成方法の開発に成功しました (図 2)。

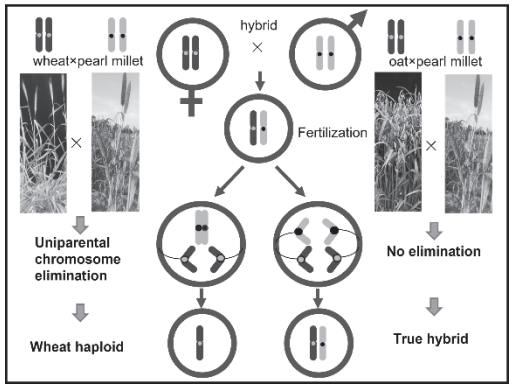


Fig.1. Chromosome elimination in subfamily distance wide crossing.

Takayoshi Ishii (Junior 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

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 centre or university and seed company is participating in this project. JSPS funding through the Yoshihiro Matsuoka (Japan) and Takashi Okamoto (Japan).

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

1. Our group will be supported by JST's FOREST program (2021 to 2027). The title of the project is "Expanding the concept of genetic resources by overcoming chromosome elimination. Creating crops that are adapted to different environments is very important for sustainable food production. Crossing with distant species is an attractive approach in plant breeding due to the different genetic background of parents. However, uniparental chromosome elimination during early hybrid embryogenesis have been reported in several species (Figure 1). In this study, bread wheat and oat belonging to the subfamily of Pooideae are used as female parents, and various *Pennisetum* species belonging to the subfamily of Panicoideae are used as pollen parents. Bread wheat and oat are important crops that are consumed all over the world. However, they are susceptible to abiotic stresses such as drought and high temperature. On the other hand, *Pennisetum* species are very tolerant to drought and high temperatures. Efforts will be made to elucidate the effects of diverse pollen parents from *Pennisetum* species on chromosome elimination. The different degrees of chromosome elimination phenomenon will be analyzed in the future to find the factor(s) controlling chromosome elimination.
2. In collaboration with Prof. Dr. Okamoto from Tokyo Metropolitan University, we have succeeded in developing the world's first method for creating hybrid plants between rice and wheat by fusing rice and wheat egg cells and sperm cells by the invitro fertilization method (Figure 2).

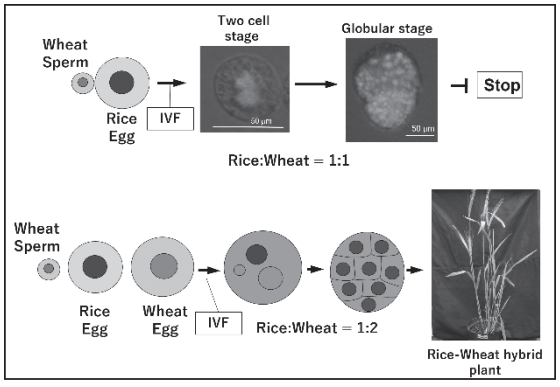


Fig.2 Rice-Wheat hybrid production via *invitro* fertilization(IVF) method.

Yasir Gorafi (Specially Appointed Associate Prof., Molecular Breeding)

The research activities from April 2021 to March 2022 included,

(1) Evaluation of the potential of the Japanese wheat in breeding heat stress tolerant cultivars.

(2) The identification of high nitrogen use efficient wheat germplasm to be used for breeding new wheat cultivars to contribute to agricultural production sustainability.

(3) Development of new wheat heat stress tolerant germplasm.

(1) Potential of Japanese wheat germplasm for breeding heat stress tolerance cultivars

Forty spring Japanese wheat lines were evaluated in three environments under heat stress conditions in Sudan. The experiments were arranged in an alfa lattice design with two replications.

The evaluated lines possessed considerable genetic variation in most of the studied traits under moderate and severe heat stress conditions ($P<0.05$). Under severe heat stress conditions, one line was one week earlier than the earliest adapted Sudanese check.

Two lines had a higher harvest index than the adapted checks under both moderate and severe heat stress conditions

In grain yield, some of the Japanese lines showed

comparable yield to that of the adapted checks. The results revealed that some of the Japanese lines had desired traits that could be used to breed better heat stress adapted bread wheat cultivars.

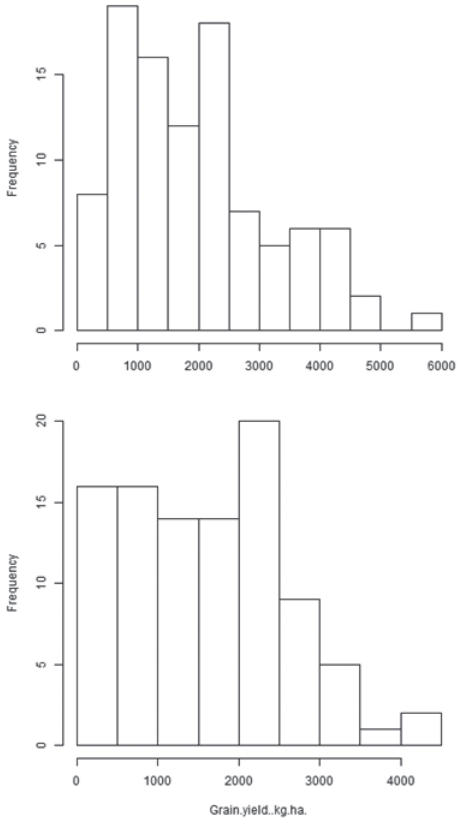


Figure 1. Frequency distribution of the grain yield (kg/ha) of the evaluated lines under moderate (a) and sever (b) heat stress conditions in Sudan

(2) Identification of efficient nitrogen utilization wheat germplasm

Climate change and depleted natural resources are among the threats that affect crop production. Nitrogen fertilizer represents the most expensive input in wheat production and accounts for about 70% of its associated gas emissions. Therefore, to sustainably feed the expected world population of 9 billion in 2050 with less environmental effect, high-yielding wheat cultivars with high input uptake and utilization efficiency are required.

One hundred forty multiple synthetic derivatives lines and other 60 elite wheat lines were evaluated under no-nitrogen and optimum nitrogen conditions at Wad Medani in Sudan to identify high-yielding germplasm with better nitrogen uptake or utilization efficiency.

The effects of the genotypes, environments, and genotype × environment interactions were significant for most of the studied traits. Nitrogen deficiency reduced the grain yield and biomass of the tested lines. Some lines experienced less reduction in grain yield and kernel weight (0-10%) than the parent cultivar Norin 61, with about 18% reduction in both grain yield and kernel weight. (Figure 2).

This experiment will be repeated in the coming seasons to validate this season's results. Also, a genome-wide association study will be conducted to identify the genomic regions associated with the high nitrogen uptake or utilization efficiency.

(3) Development of new heat stress tolerant wheat germplasm

Previous studies identified and selected heat tolerant hexaploid and tetraploid wheat lines. To produce new germplasm generation combining the tolerance of both tetraploid and hexaploid, both were crossed, and pentaploid wheat lines were produced. These lines will be crossed with elite hexaploid wheat to introduce the tolerant genes into the elite genetic backgrounds. The new wheat lines will be advanced and evaluated under heat stress conditions.

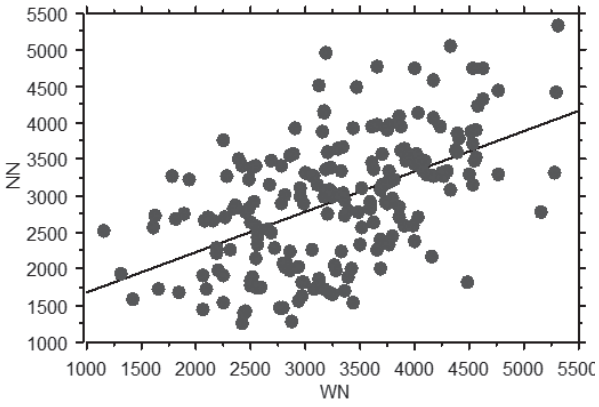


Figure 2. Relationship between the grain yield (kg/ha) under no nitrogen condition (NN) and with nitrogen condition (WN) in 140 multiple synthetic derivatives and other elite wheat lines. Some lines sowed low reduction in grain yield in response to nitrogen deficiency.

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) 非生物ストレス耐性選抜に向けたホップ育種に関する研究

これらの研究は、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. 昨年度、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。そこで、それらの系統の先祖である合成コムギを用いて、類似した性質がないかどうかを調査した。その結果、先祖と推定した合成コムギ系統と同一クラスター内にある系統に類似した性質を確認することができた (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的に測定した (Figure 2)。
3. 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. ストレス耐性を有するホップを育種するため、炭素同位体比解析・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用いることができることを確認した。

Yuji Yamasaki (Project Researcher, 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 2021 as my third contract year.

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, it was confirmed that the synthetic wheat lines in the same cluster deriving the tolerant lines had similar features (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. Also, metabolome analysis suggested that some of metabolome 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 method for the selection.

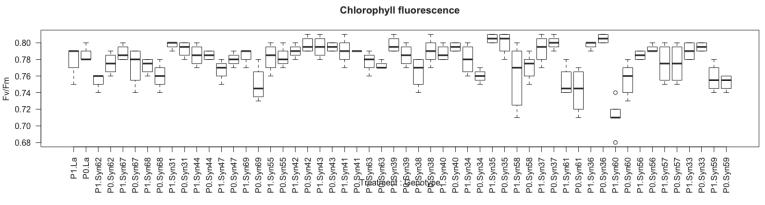


Figure 1. Chlorophyll Fluorescence in synthetic wheat lines

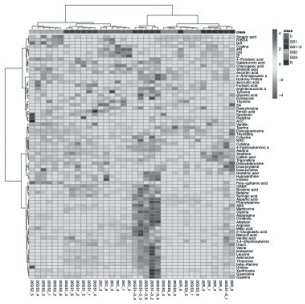


Figure 2. Metabolome analysis in seeds from heat treated plants in different development staged

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

Faisal Elhag (Visiting Prof., Renge-Livestock and Climate change)

October 1, 2020 -Sept. 30, 2021

Climate change adaptation options for dryland livestock farming in Sudan

Annual Report (October 1, 2020 – September 30, 2021)

Most of the rural poor in Sub-Saharan Africa rely, for their livelihoods and food security, on highly climate-sensitive, rain-fed, small-scale subsistence farming, pastoral herding, and direct harvesting of natural services of ecosystems. The productivity of this livelihood base is highly vulnerable to climate-related stresses. Serious environmental constraints, likely to worsen due to climate change leading to food insecurity and widespread poverty. Globally, based on changes in herbaceous production, grazing livestock are projected to decline by 7.5 to 9.6% of total stocking in rangelands, particularly in savannas south of the Sahara.

This research work compared livestock dynamics and productivity under di□erent rainfall regimes, vegetation conditions and temperatures across different agroclimatic zones and suggested adaptation interventions to build resilience and food security of pastoral and agro-pastoral communities under dryland conditions in the Sudan and similar ecological areas. **Therefore, the main aim of our research during October 1, 2020-September 30, 2021 at ALRC, Tottori University**, was to study climate change impacts on dryland livestock farming in Sudan and to propose some climate change adaptation interventions.

Data sets obtained from different sources in Sudan included research data from the Dryland Research Center (DLRC) of Sudan Agricultural Research Corporation (ARC), Sudan Meteorological Authority (SMA), Ministry of Agricultural (MOA), Range and Pasture Administration (RPA). These data sets were categorized according to agroclimatic zones, adjusted, and statistically analyzed for correlations among climatic variables, rangelands attributes and future livestock (particularly, Desert sheep) distribution in Sudan. Simple, and multiple regression analyses were undertaken for trends in climatic factors (TMIN, TMAX, rainfall), rangeland biomass productivity in relation to climatic variables, and future scenarios for Desert sheep distribution.

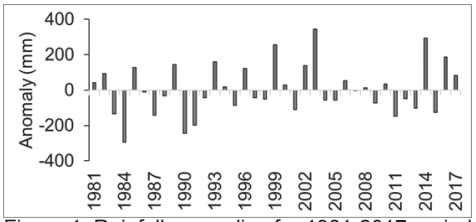


Figure 1. Rainfall anomalies for 1981-2017 period.

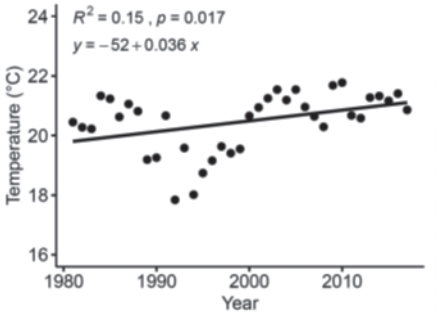


Figure 2. Trend of minimum (TMIN) temperatures (o C) (1981 to 2017)

Results: Annual rainfall anomalies, from 1981 to 2017, reflected that drought seemed to be frequent during the period from 1981 to 2017 (Figure 1). Experienced moderate to severe droughts in 1983, 1984,1987,1990,1991, 2011, and 2015 had below average rainfall. It was observed that rainfall was above average for the three consecutive years of 2006, 2007 and 2008. Results also indicated a 0.5oC decadal increase of TMIN (Figure 2).

These climatic changes negatively affected livestock productivity in terms of rangeland areas (Table 1) and feed balance situation (Table 2). This would negatively impact future distribution of Sudan Desert sheep which could be confined to limited areas in southern and along the coastal zones in Sudan (Figure 3). A paper presented at the ALRC 26th colloquium (Dec 5, 2020): entitled "Climate change adaptation options for dryland livestock farming, Sudan: Anthropogenic and climatic factors and their implications on range-livestock in North Kordofan State, Western Sudan".

Table 1. Changes in rangeland areas (ha) and biomass productivity (ton) from 1990 to 2017.

	2000	2017	% change
Biomass yield (kg/ha)	420	510	21
Rangeland area (ha)	2,340,800	984,000	-58
Biomass prodn. (ton)	983,136	501,840	-49

Table 2. Feed balance situation in livestock populated States in Sudan (2017)

Item	Gadaref	North Kordofan
Grazing area (ha)	5,048,900	12,344,900
Grasses biomass (ton)	779,661	1,267,982
Grasses productivity (ton/ha)	0.154	0.103
Browse biomass (ton)	282,967	578,327
Crop residues (ton)	3,799,094	1,232,200
Total biomass (ton)	4,851,722	3,078,509
Total TLU#	1,750,930.0	2,719,348.1
##Total feed required (ton)	4,727,511.0	7,342,240.3
Total feed available (ton)	4,851,722	3,078,509
Feed balance	134.211	(4,263,732)
% surplus/deficit	2.8	-138.5
Grazing area (km2)	50,489	123,449
Stocking density	34.7	22.0
Current carrying capacity (ha/TLU/ year)	2.8097	10.8271
Potential carrying capacity (ha/ TLU/Year)	2.8	4.54

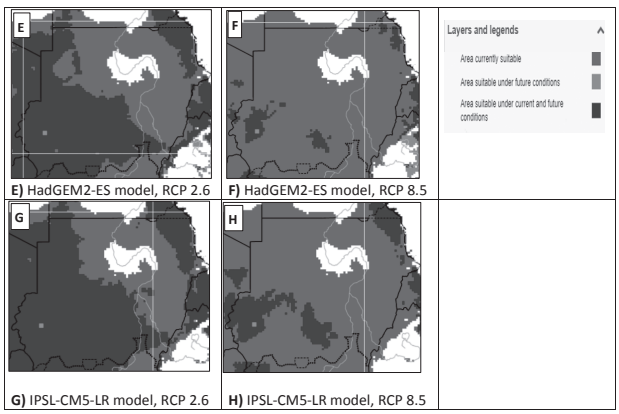


Figure 3. Future distribution of Sudan Desert sheep.

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, metribuzin, 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.

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*.

Papers presented at Conferences/ Symposia

1. Ubi, B. E. and Ishii, T. (2021) Testing herbicide entry depth as a non-destructive method for in situ root phenotyping of cowpea under a sandy field soil condition. Paper presented at the 2021 Joint Research Symposium, Arid Land Research Center, Tottori University, held 4th Dec. 2021.

2. Afuape, S. O., Ebem, E. C., David O. Igwe, D. O., and Ubi, B. E. (2021) Combating vitamin A deficiency (VAD) in Nigeria: the bio-fortified sweetpotato development and deployment Approach. Paper presented at the 141st Conference of the Japanese Society of Plant Breeding (JSB), held Online on 21st March, 2021.

3. Ubi, B. E. (2022) How shall we use the ALRC sandy field for root phenotyping? Case study with 400 Asian cowpea accessions. Presentation at the 28th Colloquium of the Arid Land Research Center, Tottori (Held Online) on 25th August, 2022

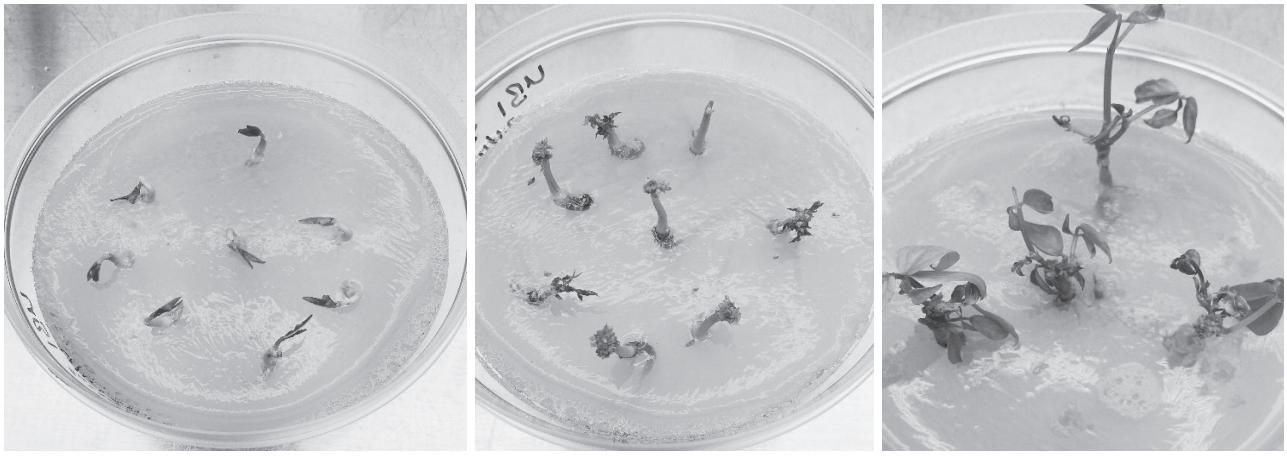


Fig. 1: A: 4-day old cultured isolated cowpea embryonic axes (EAs) with intact plumule growing in shoot induction media (SIM); B: 20-day old plantlets with induced multiple shoots after the shoot apical meristem (SAM) was excised with scissors when the cultures were 5 days old; C: 55-day old plantlets 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.

Dagnenet Sultan Alemu (Visiting Assoc. Prof. Hydrology)

October 2021 – March 2022

Developing **runoff and sediment** response time estimation models **for better environmental** planning.

This study will have three separate components

Component 1. Evaluation of lag time and time of concentration estimation methods in small tropical watersheds in Ethiopia

Component 2. Analyzing the influence of changes in land use/ land cover and management practice on lag time of peak flows for tropical watersheds of Ethiopia

Component 3. Develop improved lag time and time of concentration models for hydrologic simulation of runoff and sediment in ungauged watersheds

Component 1: Evaluation of lag time and time of concentration estimation methods in small tropical watersheds in Ethiopia

Summary of research result

Lag time (T_L) and time of concentration (T_C) are two measures of how quickly a stream responds to runoff-producing rainfall within its watershed (**Fig 1a**). These parameters are the main inputs used to estimate peak flow under flood conditions in ungauged watersheds. Many empirical methods have been proposed to estimate T_L and T_C, but the validity of none of them has been tested in small tropical Ethiopian watersheds. We compared 10 commonly used methods by using measured data from six small agricultural watersheds in three tropical climatic regions (**Fig 1b**) of Ethiopia. We statistically evaluated their performance against measured median values of T_L and T_C for 176 rainfall–runoff events. For individual watersheds, the estimates of T_L and T_C differed by up to 2.6 h and 4.4 h, respectively. Most of the empirical methods tended to substantially underestimate T_L and T_C (**Table 1**), which would lead to overestimation of runoff volume. T_L and T_C computed by two methods that consider both overland and channel flow were closest to the measured values of T_L and T_C, because such mixed flow is typical of tropical climate regions. Our results show the need for caution when empirical methods developed in regions with a particular climatic and geomorphological conditions are applied elsewhere.

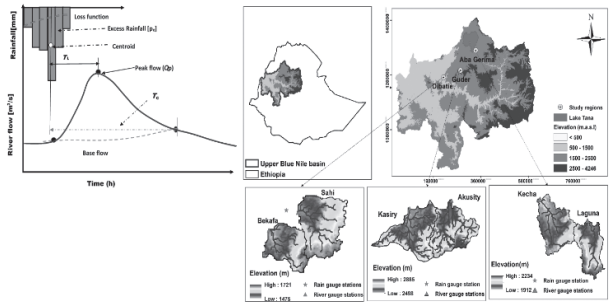


Table 1 Performance statistics of the 10 empirical methods based on medians of estimated values

		T_L			T_C		
No.	**Method**	R^2	***RSR***	***PBIAS* (%)**	R^2	***RSR***	***PBIAS*(%)**
1	USSR	0.06	1.15	35.66	0.17	1.00	0.72
2	Snyder	0.05	1.04	–293.3	0.05	1.01	–255.0
3	SCS Lag	0.21	2.18	163.0	0.22	0.56	61.51
4	FFA	0.10	1.41	27.9	0.15	1.67	60.47
5	Kirpich	0.02	1.02	65.48	0.005	4.96	65.09
6	Carter	0.003	0.68	72.79	0.002	1.00	88.32
7	SCS Velocity	0.50	1.00	–24.00	0.60	1.08	–22.37
8	Bransby Williams	0.04	1.43	–25.18	0.04	1.03	–26.30
9	Simas–Hawkins	0.70	0.58	–14.00	0.60	0.81	–24.00
10	Ventura	0.02	1.19	16.27	0.06	1.00	67.45

Component 2: Analyzing the influence of changes in land use/ land cover and management practice on lag time of peak flows for tropical watersheds of Ethiopia

Summary of research result

Peak flow response time alterations governed by the rainfall input and physical configurations of the watersheds are the main concern of several of previous research works, while other factors can also have significant effect. In view of this, the current research was employed with the aim of analyzing the dynamics in lag time (T_L) of peak flow for tropical watershed (Kecha) and sub-watersheds (Dokmit, Zengero Maderia and Wotit Minch) of Ethiopia (**Fig 2**), as influenced by land use land cover (LULC) change of 1982, 2005, and 2017 and implementation of soil and water conservation (SWC) practices since 2011. Layer maps of soil type, SWC practice and LULC change for the corresponding study periods were used for the determination of curve number (CN) values while Natural Resource Conservation Service (NRCS) hydrologic model was used to estimate TL. We statistically compared the estimated value against measured median values of TL for 30 rainfall–runoff events. The estimates T_L of 1982, 2005 and 2017 varied 9 to 19 min, 8 to 18 min and 10 to 22 min, respectively, among the Dokmit, Zengero Maderia and Wotit Minch sub-watersheds (**Fig 2 c**). The smallest (8 min) and highest (22 min) lag time of peak flow were observed during 2005 and 2017, respectively. This is due to the increment of cultivated area as an expense of bushland and forest plantation in 2005 vs implementation of SWC practices since 2011 through 2017. Smaller T_L values for Dokmit (**Fig 2 a&b**) than other sub-watersheds were mainly due to larger coverage of grazing and cultivated lands and degraded Nithic Luvisol. The results further revealed that variations in lag time of peak flow among the sub-watersheds were related to change in both land cover and SWC practices, but also to the presence of degraded areas, inherited from past human activities. Overall, such spatiotemporal flow response time analysis can provide useful information for proper design of sustainable development strategies for particular niches in the tropical highlands of Ethiopia and elsewhere with similar environmental settings.

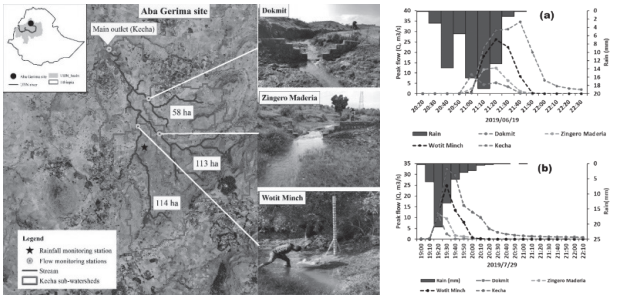


Fig 2. Location of Aba Gerima site in the UBN basin of Ethiopia, and rainfall and runoff monitoring stations in Kecha and its sub-watersheds

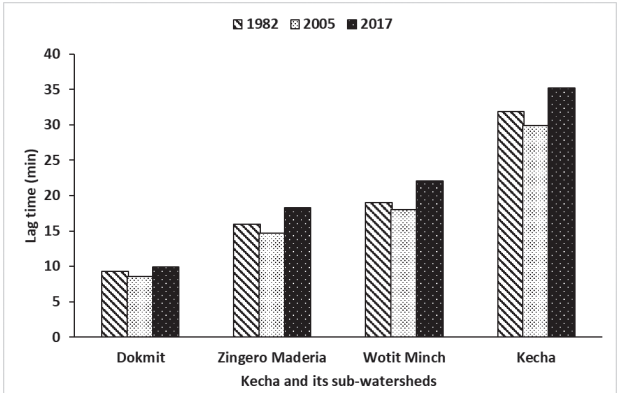


Fig 2C. Estimated lag time variation at Kecha and its sub-watersheds during 1982, 2005 and 2017 LULC

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

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

(1) Examining the past climate (120 years) of Ethiopia, East Africa.

This study examined the spatial-temporal variability and trends of Ethiopian climate (rainfall and temperature) from 1901 to 2020. We extracted monthly rainfall and temperature (maximum, minimum and mean) data from the latest version of Climatic Research Unit (CRU 4.05) dataset for 365 grid points. Five different homogeneous rainfall zones were developed using long-term monthly peaks, seasonal rainfall patterns, and pixel-based monthly rainfall correlation coefficient techniques. Rainfall and temperature data collected at 235 and 145 stations were used to validate the CRU dataset. Statistical software's such as XLSTAT, R, and Python integrated with ArcGIS 10.4 were used for Spatio-temporal variability and trend analysis.

The results revealed that high spatial (Fig.1) and temporal rainfall and temperature variability on the annual and seasonal time scales were observed across rainfall zones. However, for both climate parameters, the inter-seasonal variability is more pronounced than the interannual variability in all rainfall zones. The changes in the annual series of rainfall in Zone-1, Zone-2, Zone-3, and Zone-5 have been dominated by variations in summer (JJA) rainfall. On the contrary, the variation in autumn (MAM) rainfall determines the change in the annual rainfall series in Zone-4. The annual scale spatial trend statistics of rainfall revealed that approximately 45% and 52% of the country showed non-significant decreases (up to –1.39) and increasing (up to +1.22) trends from 1901 to 2020. However, statistically

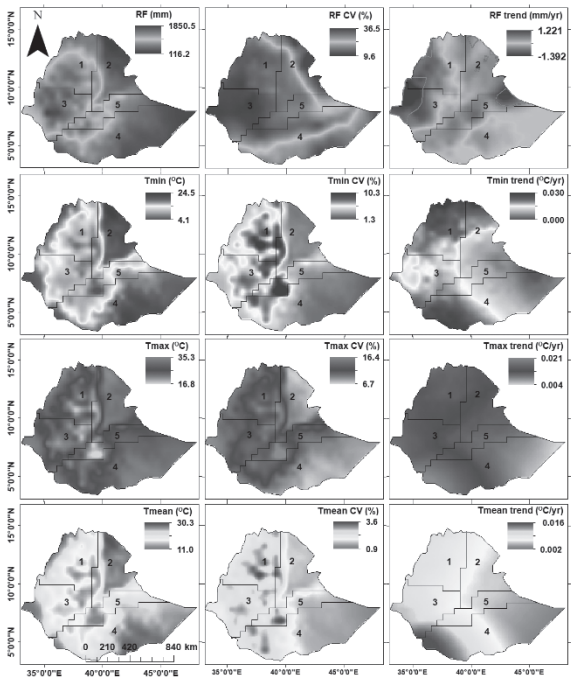


Fig. 1 Spatial distribution of annual rainfall (RF), minimum temprature (Tmin), maxmumum tempratre (Tmax), and average temprature (Tmean) during the period 1901–2020: mean value (left side), coefficient of variation (CV, middle) and trend (rate of change measured as the slope linear trend; right side). Red coloured curves represent the statistical significance level at α = 0.05.

significant (α = 0.05) spatial trends in rainfall were observed in some areas (22% out of 97%) of the country at annual and seasonal time scales whereas no-significant temporal rainfall trends were observed in all seasons (except summer in Zone-3) and rainfall zones (Table 1). The long-term precipitation concentration index spatial and temporal analysis result also revealed that the country exhibited moderate to strongly regular annual and seasonal rainfall distribution except for the summer season, indicating high rainfall seasonality through the course of the year. The annual and seasonal standard precipitation index values were identified as the wet and drought years happened in Ethiopia, a higher percentage of negative anomalies than positive anomalies were observed during the study period. Local and national deficit and excess rainfall years (13–20 years) occurred over 120 years.

Unlike rainfall, there was a spatial and temporal significant (α = 0.05) long-term monotonic and non-homogeneous increasing trend in annual and seasonal temperature in all rainfall zones of the country (Table 1). The spatial and temporal increasing trend rate of mean temperature (Tmean) at annual and seasonal timescale ranged from 0.24 oC to 1.92 oC and 0.72 oC to 1.08 oC over 120 years, respectively (Fig.1 and Table 1). In all rainfall zones, the Tmin increased at a higher rate than the Tmax and Tmean over 120 years at spatial and temporal scales and the change in Tmean highly influenced by Tmin (Tmin). Increasing temperatures are expected to increase evapotranspiration, increase water losses by evaporation, and cause more severe droughts across large parts of the country. Thus, areas severely affected by drought or deficit rainfall require particular attention in developing sustainable adaptation measures to minimize the possible impacts on agricultural activities. The study will contribute to a better understanding of the past climate of Ethiopia under different rainfall zones for future climate projection and can be used in planning for adaptation and mitigation measures against a changing climate and extremes.

Table 1 Monotonic trend test for annual climate variables from 1901 to 2020 in five climate zones of Ethiopia.

Climate variable	Zone	Mann–Kendall test			Sen's slope		
		Zc	*P*	*Ho*[a]	*S*	*Lb(95%)*	*Ub(95%)*
Rainfall	1	–1.30	0.192	*A*	–0.381	–0.964	0.209
	2	1.08	0.281	*A*	0.241	–0.219	0.665
	3	–1.61	0.107	*A*	–0.516	–1.171	0.095
	4	0.29	0.773	*A*	0.068	–0.363	0.456
	5	1.35	0.176	*A*	0.451	–0.191	1.100
Min. Temperature	1	8.03	< 0.0001	*R*	0.011	0.009	0.013
	2	6.12	< 0.0001	*R*	0.007	0.005	0.009
	3	8.23	< 0.0001	*R*	0.011	0.009	0.013
	4	6.51	< 0.0001	*R*	0.007	0.005	0.009
	5	6.04	< 0.0001	*R*	0.006	0.004	0.008
Max. Temperature	1	3.24	0.001	*R*	0.005	0.002	0.009
	2	2.64	0.008	*R*	0.004	0.001	0.007
	3	4.15	< 0.0001	*R*	0.007	0.004	0.010
	4	5.28	< 0.0001	*R*	0.007	0.004	0.009
	5	3.47	0.001	*R*	0.004	0.002	0.007
Mean Temperature	1	6.03	< 0.0001	*R*	0.008	0.006	0.011
	2	5.44	< 0.0001	*R*	0.006	0.004	0.008
	3	6.70	< 0.0001	*R*	0.009	0.007	0.011
	4	6.52	< 0.0001	*R*	0.007	0.005	0.008
	5	5.66	< 0.0001	*R*	0.006	0.004	0.007

H_0^a is the null hypothesis that there is no monotonic trend in the time series for annual climate variables; The null hypotheses are accepted (A) or rejected (R) at significance level α=0.05. S: Sen's slope; CP: change point; Lb and Ub: lower and upper bound of Sen's slope respectively.

（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。

また、「限界地プロジェクトⅡ」（乾燥地植物資源を活用した耕作限界地における作物生産技術の開発　－世界の耕作限界地における挑戦と実証－）において、年間降水量 300 ミリメートル台の降雨依存農業地域で、持続的な生産を可能にする農業技術パッケージ作るため、乾燥地植物資源の収集と評価を進めた。

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。
- コムギ系統を保存した。
- 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。

Interspecific hybrid *Jatropha*

(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.

We are also promoting the special project "Project Marginal Region Agriculture II (Development of crop husbandry technology in marginal rainfed environment using dryland plant resources -Challenge and demonstration in the global marginal regions-)". In this project we are collecting and evaluating of dryland plant resources in order to create an agricultural technology package that enables sustainable production in the regions with about 300 mm annual rainfall.

For the fiscal year 2021 we promoted the following research.

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

Propagation of wheat

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

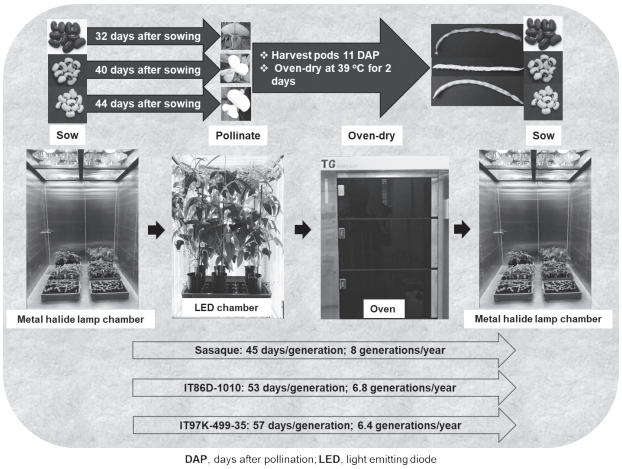
The activities of my research in FY2021 were divided into the following sub-titles:

1. Cowpea speed breeding using regulated growth chamber conditions, CO_2 supplementation and cultivation of seeds of oven-dried immature pods
2. Development and testing of potential centromere-specific histone 3 (CENH3)-mediated cowpea genome elimination/haploid inducers
3. Genetic characterization of a spontaneous cowpea mutant identified during the FY2021 field cultivation

Cowpea is a dryland crop with potential to improve food security in sub-Saharan Africa, where it is mostly produced and consumed. It is an annual seasonal crop, whose cultivation is restricted to the warm months of the year. As such, only one breeding generation is feasible in a year, which is inadequate for breeding programs that require many breeding generations. To circumvent the barrier imposed by the seasonal cultivation of cowpea, we developed and validated, for the first time, an efficient speed breeding protocol which potentially accommodates seven to eight breeding generations per year for three genotypes of cowpea. An application for this protocol to be patented has been approved by Tottori University (P2022-002), and a research article reporting the detailed procedure and empirical results validating the protocol is under review for publication.

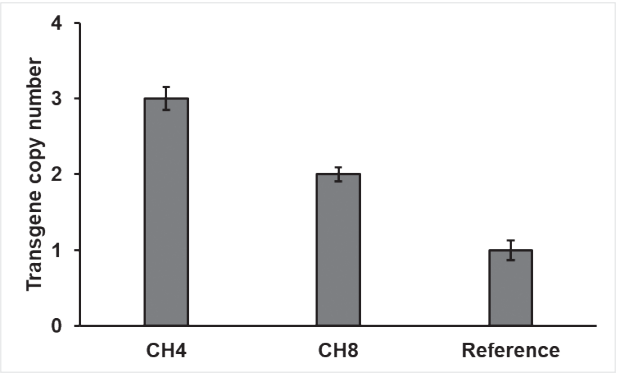
Doubled haploid breeding allows homozygous lines to be produced in a single generation, thereby reducing the time needed for the development and evaluation of improved plant cultivars. The application of doubled haploid technique of breeding, i*n vitro or in vivo*, has yet not been reported for cowpea. To test the possibility of CENH3-mediated in vivo haploid induction in cowpea, as reported for other plants, we combined cowpea CENH3s (CENH3.1 and CENH3.2) wild-type and CRISPR/Cas9-edited alleles to produce potential haploid inducers. As cowpea has two functional variants of CENH3, we also produced candidate haploid inducers by complementing cowpea CENH3s knockout alleles with other species CENH3. Two cowpea transgenic lines carrying different copies (two and three) of the transgene were crossed with the CRISPR/Cas9-edited cowpea genotypes to produce potential haploid inducers.

Mutations serve as sources of variation in plant populations, thereby aiding the discovery of useful genes for crop improvement. As compared to induced mutations, spontaneous mutations are rare in plants and their usefulness can only be determined through a thorough genetic and molecular analyses to uncover the nature of the mutation, transmission pattern and function of the mutant locus. In the FY2021 field cultivation of cowpea at ALRC, we identified a unifoliate inverted leaf mutant of IT86D-1010 cowpea. Six generations of the mutant were studied in the ALRC Subtropical Growth Chambers. While observing the transmission rate of the mutant locus over six self-pollinated generations, reciprocal crosses between the mutant genotype and three cowpea genotypes (IT86D-10110, IT97K-499-35 and Sasaque) were made, and the hybrids were evaluated. Intriguingly, the mutation was found to be dominant, a rare occurrence in both induced and spontaneous mutations. Shotgun sequences of the mutant and the wild-type (IT86D-1010) will be analyzed to reveal the molecular basis of the mutation. A clear understanding of the genetic characteristics and molecular basis of the mutation will provide insights that would enable adequate utilization of the mutant locus for breeding.



DAP, days after pollination; **LED**, light emitting diode

Representation of a cowpea speed breeding protocol validated for three genotypes of cowpea

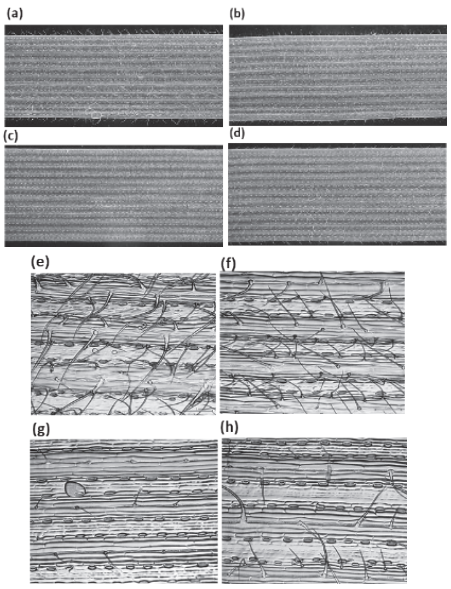


Transgene (Arabidopsis thaliana CENH3) copy number in transgenic cowpea genotypes tested for haploid induction

Nasrein Mohamed Kamal (Project researcher, Marginal Region Agriculture Projects of Tottori University

(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; leaf hair production increases tolerance to drought, and 2) morphological and physiological traits are affected due to the absence or presence of leaf hair gene *LH2*, 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 well-watered (WW) and water deficit (WD) 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, without *LH2*, and NIL from CS, with *LH2*, were evaluated under WW and WW conditions. Morphological, physiological, metabolome (LC-MS), minerals content (ICP-MS), and carbon isotope composition (IR-MS) analyses were conducted to test and validate the three hypotheses. We also studied the impact of *Hl2* gene on the stomata density and size under WW and WD. A preliminary result indicated that introducing *Hl2* improves the drought tolerance of CS. Moreover, leaf hair is physiologically active under WD, mainly through the potential production of enzymes that contribute to phenolic compounds and amino acids with important roles in drought stress tolerance. We propose that the introgression of *Hl2* (leaf hair) is associated with drought tolerance of wheat.

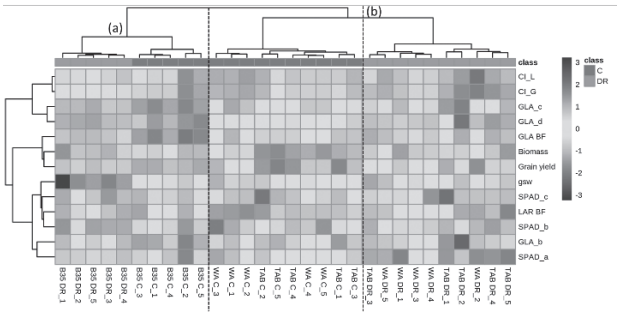


Phenotypes of leaf surface, view of KB and NILKB (a, b) and CS and NILCS (c, d), and microscope image for leaf adaxial side of KB and NILKB (e, f) and CS and NILCS (g, h).

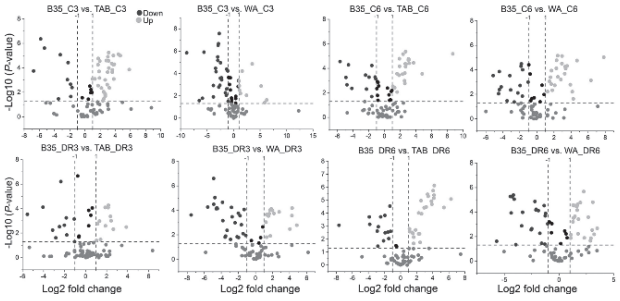
(2) Sorghum: New insights into the physiological, mineral, and biochemical responses of stay-green and non-stay-green sorghum genotypes under post-flowering drought stress

Sorghum is an important cereal crop grown in arid and semi-arid regions where drought restricts production. Stay-green sorghum plants can retain green leaf area for longer under drought conditions and yield higher than their senescent counterparts. Understanding plants' physiological, metabolic, and biochemical responses to drought stress and mining the tolerance associated with stay-green will be significant for cultivating drought-tolerant crops.

The study aimed to understand the tolerance mechanism behind the stay-green trait through the differential nutritional, biochemical, and physiological changes in leaves and grains in response to drought stress in B35, stay-green (SG), Wad Ahmed (moderately SG), and Tabat (non-SG) to post-anthesis drought (DR). We report the influence of DR on sorghum yields and nutritional composition based on artificially induced DR conditions and irrigated control (CN). Results showed that DR affects all physiological, yield-related traits, nutrients contents, and metabolites concentrations of the 3 lines. These changes were observed in seed and leaf tissues. Physiological, nutritional, and metabolome response analysis suggested that SG line have significant variations in the corresponding associated metabolites, minerals and physiological responses under CN and DR.



Hierarchical clustering analysis showed two main groups: group (a) represents B35 under the control and drought, while group (b) represents TAB and WA genotypes under the control and drought condition. Group (a) includes the parameters associated with drought tolerance in B35.



Volcano plot of metabolites for stay-green and non stay-green lines under control and drought stress. Blue dots (significantly down-regulated) and red dots (significantly up-regulated).

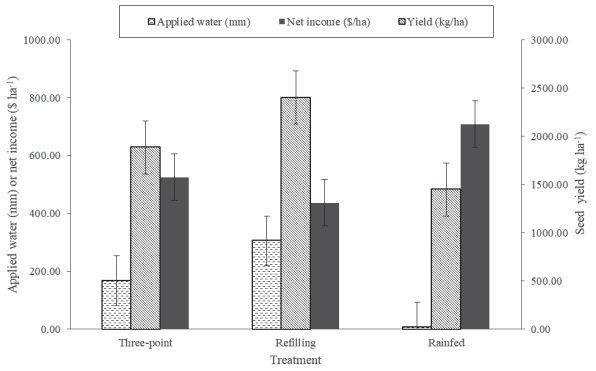
Hassan Mohamed Fahmy Abdelbaki (Project Researcher, Dryland Agriculture)

My research focuses mainly on the following subjects:

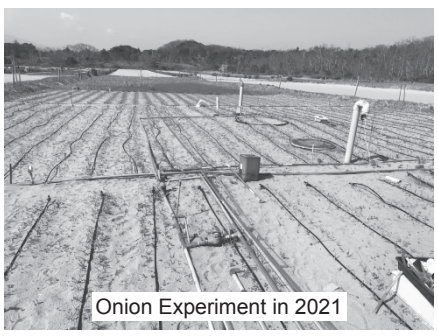
1. Simulation-Based Schemes to Determine Economical Irrigation Depths Considering Volumetric Water Price and Weather Forecasts.
2. Estimation of Root Water Uptake Parameters for Sweet Potatoes.
3. Measuring Soil Hydraulic Properties and Calibrating Soil Moisture Sensors.

In this fiscal year, I carried out different field and Lab experiments to achieve those objectives as follows:

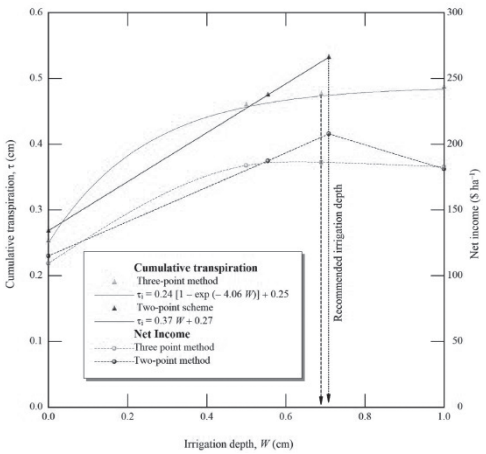
1. I continued my research in Morocco by completing one of winter experiments on May 2021 and carrying out a new experiment for winter season 2021/22. These activities were conducted as a collaboration research with the International Center for Agricultural Research in the Dry Areas (ICARDA) in Morocco as follows`:
   - In 2020/21, a field experiment was carried out to assess the feasibility of a simulation scheme used to determine irrigation depths considering volumetric water pricing and weather forecasts in comparison to rain-fed agriculture and a simulation-based refilling scheme used to return the volumetric water content to field capacity.
   - In 2021/22, the same experiment was repeated for the same crop with a different experimental design to assess the schemes under the drought-year condition.
2. I continued carrying out a field experiment for onion crop grown in a sandy field of ALRC in 2020/21. Four treatments, a) automated irrigation system managed with tensiometers; b) two-point simulation scheme; c) three-point simulation scheme; and d) refilling scheme based on simulation, were carried out to evaluate their effectiveness in terms of water application (irrigation depths), yield production and gross net income. We harvested the crop in June 2021. We decided to terminate the experiment early as the crop was highly stressed under the snow conditions, which affected the growth of leaf area that affected the final yield.
3. I carried out a field experiment for summer crop, sweet potatoes grown in a sandy field of ALRC in 2021. The experiment was carried out as same as mentioned in the point 2. We transplanted seedlings on June 18 and harvested on November 2.
4. I carried out a pot experiment to determine parameter values of stress response function for both drought and salinity stresses for sweet potatoes. Results were used for the simulation procedure of a field experiment (point 3).
5. I carried out different Lab experiments to determine the hydraulic properties of Merchouch's clay soil in Morocco and to calibrate different soil moisture sensors for Tottori sandy soil.
6. I was invited as a speaker for 60th of workshop of the Japanese Society of Irrigation, Drainage and Rural Engineering (JSIDRE), soil physics section "Management of water, salinity, and nutrient in drylands using numerical models", October 2021. Lecture title was "Innovative schemes to optimize irrigation depths using numerical simulation and weather forecasts."
7. I participated as an instructor for field experiments carried out in ALRC, JICA training course, Knowledge Co-Creation Program (Groups & Region Focus), October 2021.



A sample of experiment results (2021/22)



Soil hydraulic properties
&
Sensors calibration



Example of optimizing irrigation depth at maximal net income (sweet potatoes experiment, 2021)

Michael O. Itam (Project Researcher)

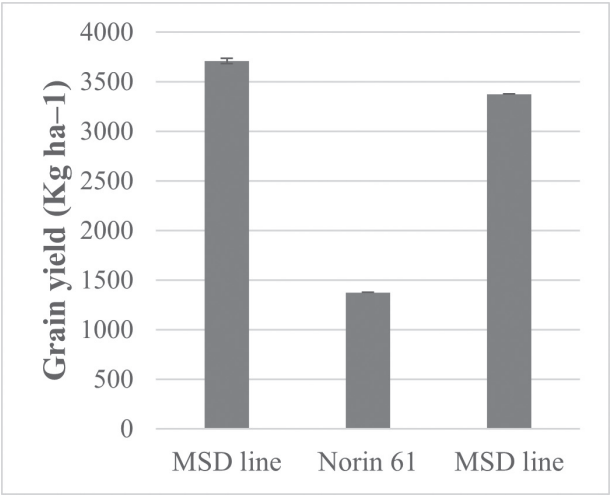
Development of wild tetraploid wheat germplasm for breeding heat-tolerant bread wheat by accumulating QTLs

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 2021/2022 fiscal year, 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 abiotic stress tolerance.

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



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

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。

(2) 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)。有用菌株の植物への作用機構の解明のため、光合成、植物の無機成分吸収への影響、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を進めている。

(3) これまでに得られた植物に耐塩性を誘導する細菌数菌株を用いて、塩処理条件下におけるトマト果実の収量・品質への影響を調査した。塩処理条件下における果実収量への影響は栽培時期 (春夏作・夏秋作)・接種方法および菌株の種類で異なったが、春夏作・夏秋作で共通して収量を向上させる菌株があった。また、細菌接種により栽培したトマトは、無接種区と比べて果実の糖度・酸度の変化は小さく、細菌接種による果実品質への悪影響はないことがわかった。

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。

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.

(2) 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). To elucidate the action of the plants inoculated with the selected strains, I investigate their effects on photosynthesis and plant absorption of inorganic components, induction of expression of related genes in plants, and production of antibacterial substances and plant growth-promoting factors by bacterial strains.

(3) Using several bacterial strains that induce salinity tolerance in plants obtained in our studies, the effects on yield and quality of tomato fruit under salinity conditions were investigated. The effects on fruit yield under salinity conditions differed depending on the growing season (spring-summer and summer-fall), inoculation methods, and bacterial strains, but some strains increased yield in both spring-summer and summer-fall crops. In addition, tomatoes grown by bacterial inoculation showed smaller changes in sugar content and acidity compared to those grown without bacterial inoculation, indicating that bacterial inoculation had no adverse effect on fruit quality.

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*.

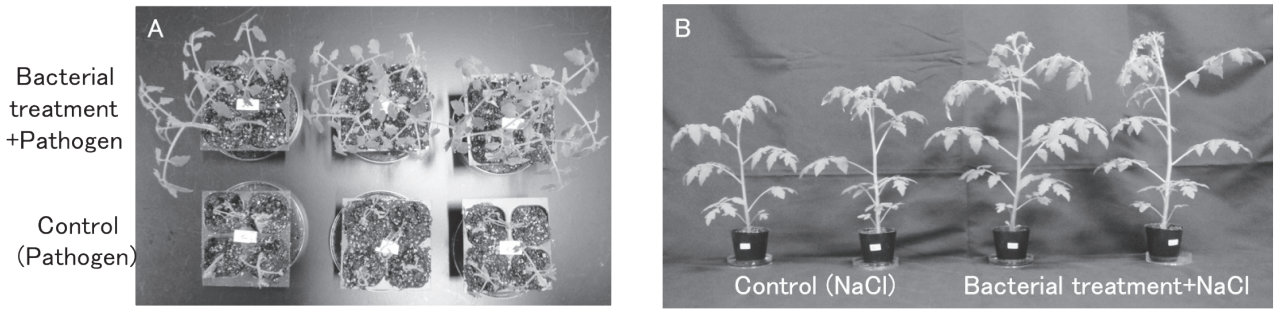


Fig. 1 Induction of disease resistance against bacterial wilt disease (A) and salinity tolerance (B) in tomato plants by the inoculation of same bacterial strain of *Pseudomonas* sp.

1.2　研究プロジェクト・教育プログラム

(1) 限界地プロジェクト第 2 期

限界地プロジェクトは、乾燥地植物資源を活用し、乾燥耕作限界地において作物生産を持続的に可能にする技術を開発することを目的とする。このため、第 1 期（「乾燥地植物資源を活用した天水栽培限界地における作物生産技術の開発〜世界の耕作限界地における持続的開発を目指して〜」（平成 27 年度〜平成 30 年度）では、高温耐性コムギの開発や自動補助灌漑技術等を組み合わせ乾燥耕作限界地における栽培技術パッケージを開発し、ICARDA やスーダン ARC にデモンストレーションフィールドを設けて、研究者、技術者、生産者、政策決定者等に対し成果の発信を行った。第 2 期（令和元年度〜令和 3 年度）では、副題を「〜世界の耕作限界地における挑戦と実証〜」に変更し、第 1 期の成果を発展させ、広範な植物資源を高度に活用することで、耕作限界地において安定･持続的な農業生産を可能にする､「発展型技術パッケージ」の開発を行っている。さらに、現地ニーズに即した技術パッケージの最適な適用を見出すことを目標にして研究を行っている。（プロジェクトリーダー:辻本壽）

研究内容

本プロジェクトは、育種研究グループ、栽培研究グループ及び、乾燥地植物資源バンク室の 3 つのチームで構成されている。

●育種研究グループ（リーダー：辻本壽）

1.耕作限界地のストレスに耐性をもつ高収量・高品質穀物の遺伝的改良に関する遺伝育種研究
2.乾燥地に適した食料及び燃料作物のストレス耐性分子機構の解明と高度利活用
3.乾燥地において収量増産に寄与する麦類作物の脱粒性現象の解明
4.乾燥地未利用遺伝資源の高度利用に向けた染色体解析

●栽培研究グループ（リーダー：藤巻晴行）

1.内在菌類・菌根菌感染による作物の耐乾性・耐暑性の付与
2.乾燥条件下における植物成長モデリング・適正栽培システム構築
3.乾燥地における持続的草地管理技術の開発
4.乾燥地における持続的栽培のための効率的水利用、土壌保全技術の確立

●乾燥地植物資源バンク室

1.乾燥地植物資源、植物情報の収集拡大による充実
2.海外連携機関ジーンバンクとの植物材料の交換

1.2 Research Projects and Training Programs

(1) Project Marginal Region Agriculture (2nd phase)

The Project Marginal Region Agriculture aims to develop technologies to enable sustainable cropproduction in marginal dryland farm by utilizing dryland plant resouces. For this purpose, in the first phase entitled “Development of crop husbandry technology in marginal rainfed environment using dryland plant resources – Toward sustainable improvement in global marginal regions (FY 2015-2018)” a package of cultivation technologies in marginal dryland area was develped by combining the development of high temperature tolerant wheat and automatic supplementary irrigation tehcnology, and the results were disseminated to researchers, engineers, producers and policy makers at ICARDA in Morocco and ARC in Sudan. In this second phase (FY 2019-2021), the subtitle of the project was changed to “Challenges and Demostration in the Global Marginal Regions” to develop an “advanced technology package” that will enable stable and sustainable agricultural production in the rainfed cultivation lands by developing the results of the first pahse and making advanced use of wide range of plant resouces. In addition, we are conducting research with the goal of finding the best application of the technology package to meet local needs. (Project leader: Hisashi Tsujimoto)

Contents of the project

This project consists of three research groups (RG); Breeding RG, Husbandry RG, and Laboratory of Arid Land Plant Resources.

● Breeding Research Group (Leader: Tsujimoto, H.)

1. Genetic studies on improvement of high yielding and high quality cereals tolerant to stress in marginal agricultural regions.
2. Elucidation of stress tolerant mechanisms of food and fuel crops suitable for dryland and their advanced utilization.
3. Genetic studies of grain shattering phenomenon leading loss of yield in dryland.
4. Chromosome analysis for advanced utilization of unused genetic resources in dryland.

● Husbandry Research Group (Leader: Fujimaki, H.)

1. Enhancement of drought and heat stress tolerance by plant-endophyte/mycorrhiza interaction
2. Modeling plant growth under drought condition and development of appropriate crop husbandry system
3. Development of a sustainable grassland management technologies in dryland
4. Development of an efficient water-harvesting and soil conservation system in dryland

● Laboratory of Arid Land Plant Resources (LALPR)

1. Enhancement of dryland plant resources and plant information by expanding the collection.
2. Exchange of plant materials with the genebanks in overseas partner institutions.

(2) 乾燥地×温暖化プロジェクト

乾燥地研究センターでは、共同利用・共同研究拠点強化プロジェクトとして、「砂漠化地域における地球温暖化への対応に関する研究（通称：乾燥地 × 温暖化プロジェクト）」（平成 29 年度～令和 3 年度）を開始した。

温暖化の進行とともに極端な気象現象が増加すると指摘されている。砂漠化地域においても、地球温暖化が原因と考えられる熱波・干ばつといった気象災害が頻発し、食糧不足など生活を直撃する影響が生じている。本プロジェクトでは、①熱波･干ばつ等の将来気候の解析を行い、②これらの砂漠化・農業への影響を明らかにし、③これらのリスクに対する適応･砂漠化対処策の開発を行う。（プロジェクトリーダー：山中典和）

研究内容

本プロジェクトは、将来気候グループ、砂漠化対処グループ及び、乾燥地農業グループの 3 つのグループで実施する。

●将来気候グループ（リーダー：黒崎泰典）
①将来気候解析
主な研究対象地域：モンゴル、スーダン
- GCM で計算された気候データ（CMIP5 など）を用いた乾燥度指数など将来気候の解析
- 熱波や干ばつなどの気象災害の変化を予測

●砂漠化対処グループ（リーダー：衣笠利彦）
②影響評価及び③適応策・砂漠化対処策の開発
主な研究対象地域：モンゴル
- 砂漠化（乾燥地における植生や土地の劣化）に対する温暖化の影響評価
- 温暖化に適応した持続的な草原利用法の提案、ダスト警報システムの精度向上等

●乾燥地農業グループ（リーダー：坪充）
②影響評価及び③適応策・砂漠化対処策の開発
主な研究対象地域：スーダン
- 熱波や干ばつによる乾燥地の農業生産等への影響を評価
- 耐暑・耐乾性作物の開発、乾燥地栽培技術の発展

これらの研究は、乾燥地研究センターが国際共同研究等で構築してきた学術ネットワークを活用して、モンゴル気象水文環境情報研究所（IRIMHE）、スーダン農業研究機構（ARC）、スーダン気象局（SMA）等と連携して推進する。

令和 3 年度、3 件の共同研究（継続課題）を実施した。令和 4 年 3 月には 5 年間のプロジェクト成果をまとめた書籍「気候変動と乾燥地：研究の最前線から」を丸善出版 (株) より出版した。

(2) Project ICC × DRYLANDs

ALRC has started a five-year project called “Impacts of Climate Change (ICC) on Drylands: Assessment and Adaptation,“ or “Project ICC×DRYLANDs” for short in FY 2017, aiming to enhance its function as a Joint Usage/Research Center.

It is pointed out that global warming increases the frequency of extreme weather events. Disasters such as heat wave, drought etc., frequently occur in drylands as well, and they have impacts like food scarcity. In this project, ALRC’s research team will 1) conduct analyses of future climate from the viewpoint of such disasters, 2) assess their impacts on desertification and agriculture in drylands, and 3) develop adaptation technologies to mitigate their associated risks. (Project leader: Yamanaka, N.)

Contents of the project

This project consists of three research groups; Future Climate Group, Combat Desertification Group, and Dryland Agriculture Group.

● **Future Climate Group** (Leader: Kurosaki, Y.)
1) Analyses of Future Climate Data
Major Research Regions: Mongolia and Sudan
- Analyses of future climate (e.g., Aridity Index) using GCM’s outputs such as CMIP5 etc.
- Prediction of disasters such as heat wave and drought, etc.

● **Combat Desertification Group** (Leader: Kinugasa, T.)
2) Assessment of Climate Change Impacts & 3) Development of Adaptation Technologies
Major Research Region: Mongolia
- Assessment of climate change impact on desertification (degradation of vegetation and land)
- Proposal for sustainable grassland management adapted to climate change; Improvement of dust early warning system, etc.

● **Dryland Agriculture Group** (Leader: Tsubo, M.)
2) Assessment of Climate Change Impacts & 3) Development of Adaptation Technologies
Major Research Region: Sudan
- Impact assessment of heat wave, drought, etc. on agriculture in drylands
- Development of heat and drought tolerant crops and cultivation technologies coping with heat wave and drought

In this project, ALRC promotes collaborative researches with Information and Research Institute of Meteorology, Hydrology and Environment (IRIMHE, Mongolia), Agricultural Research Corporation (ARC, Sudan), and Sudan Meteorological Authority (SMA, Sudan).

In FY 2021, three subjects of collaborative research (continued) were conducted. In March 2022, we published a book entitled "Climate Change and Drylands: The Cutting Edge of Research," from Maruzen Publishing Co. It summarized the outcomes of our five-year project.

（3）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。

2021 年度は、ガリ侵食のモデリング、人間活動や気候変動に対する水文学的・堆積学的反応のモデル化、土壌損失の低減と土地生産性の向上に向けた生物物理学的・土壌改良的な土地管理手法の有効性、テフ（Eragrostis tef）作物の生産性向上のための農学的・遺伝学的研究、家畜の生産性向上のための改良された飼料と給餌方法、土地を持たない若者や女性のための SLM 関連の収入創出活動のアプローチなどの研究を行った。3 月には、オンラインで、鳥取大学、エチオピア（バハルダール大学等）、東京大学、島根大学のプロジェクトメンバーや JICA、JST 関係者をつないで、第 5 回 SATREPS-Ethiopia Project Annual Workshop を開催し、2021 年度のプロジェクトの進捗状況を確認するとともに、2022 年度の活動計画を承認した。

(3) 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.

In FY 2021, we had conducted researches dealing with modeling of gully erosion development, modeling of hydrological and sediment responses to human activities and climate variability, effectiveness of bio-physical and soil amendment land management practices in reducing soil loss and improving land productivity, agronomic and genetic studies to improve productivity of Eragrostis tef-crop, improved forages and feeding regime for livestock productivity improvement and approaches for SLM-related income generating activities for landless youth and women. In March, the 5th Annual Workshop of the SATREPS-Ethiopia Project was held inviting project members from Tottori, Ethiopia, Tokyo and Shimane via online (Zoom) and reviewed the FY2021 project's progresses and approved the FY2022 activity plan.

（4）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3年度は、引き続きCOVID-19の世界的蔓延により、スーダンへの入国および同国内の都市間移動制限のため、予定していた国内研修、農民学校等の事業を実施できなかった。しかし、毎週現地と遠隔会議を行い、研究材料の栽培調査、ベースラインサーベイを行い、イノベーションプラットフォームや現地研修会も実施することができた。また、コンテナハウスの建設は竣工し、コンバインハーベスターや導入する実験機器の購入契約を交わすことができた。3 月には専門家を 1 名派遣でき、令和 4 年度からのプロジェクトの現地実施の準備を行った。

(4) 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

Reseasrch 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 FY2021, due to the continued global outbreak of COVID-19 and restrictions on entry into Sudan and movement between cities within the country, the planned in-country training, farmer schools, and other projects could not be implemented. However, we were able to conduct weekly teleconferences with the local communities, conduct cultivation surveys and baseline surveys of research materials, and hold innovation platforms and local training sessions. The construction of the container house was completed, and contracts were signed for the purchase of a combine harvester and experimental equipment to be introduced.

1.3 共同研究 / Joint Research

(1) 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（国立研究開発法人 国立環境研究所地球システム領域） Naishen Liang (National Institute for Environmental Studies Earth System Division)		
研究課題 Research Subject	アジア地域を中心とした土壌呼吸および CO2 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 CO2 exchange in Asian region		
共同研究要旨 Summary of Joint Research	We focused on the CO2 flux and related environmental monitoring in domestic sites in the year 2021 because we could not conduct any business trips to the oversea sites due to COVID-19. In the site of Tottori sand dune, we conducted CO2 flux measurement (soil respiration and CO2 exchange) in 4 plots that dominated by *Artemisia capillaris*, *Vitex rotundifolia*, and *Carex kobomugi*, *Ischaemum anthephoroides*. Soil temperature was the primary factor controlled soil respiration, and soil respiration exponentially increased along with the seasonal rise of the soil temperature at the depth of 30 cm. On the other hand, there was no significant relationship between soil moisture at the depth of 30 cm and temperature-normalized soil respiration (the ratio of observed soil respiration against modeled soil respiration based on soil temperature response of soil respiration). That was the contrasting result from the data in 2020 when soil respiration was remarkably decreased in some plots due to drought stress in August. Our results suggested that drought stress on soil respiration does not occur every summer even in the coastal dune ecosystem where water retention capacity was relatively low and easy to be influenced by drought stress. We conducted continuous monitoring for soil respiration and heterotrophic respiration using automated chamber measurement systems (stationary type). The Higashi-Hiroshima site belongs to the Seto Inland Sea climate, and summer (July to August) precipitation is small. However, there was exceptionally large precipitation in August 2021, and the relationship between soil moisture and temperature-normalized respiration (soil respiration and heterotrophic respiration) during summer (July to September) was relatively minor compared with the summer in 2020. The tendency was the same in the Tsukuba site. There was a positive relationship between soil moisture and temperature-normalized respiration from July to September in 2020, but the relationship was relatively weakened in the summer in 2021 due to large precipitation from July to August.		

特定研究 2 Specific Research 2		対応教員 Corresponding Staff	坪　充 Tsubo, Mitsuru
研究代表者 Principal Researcher	須藤　重人（国立研究開発法人農業・食品産業技術総合研究機構農業環境変動研究センター 気候変動対応研究領域） Sudo, Shigeto (National Agriculture and Food Research Organization Division of Climate Change Mitigation Research, Institute for Agro-Environmental Sciences)		
研究課題 Research Subject	ウガンダ共和国の農耕地における温室効果ガス排出のモニタリングと削減技術開発に関する調査研究 Greenhouse Gas Monitoring and Mitigation Study at Agricultural Field in Uganda		
共同研究要旨 Summary of Joint Research	This study's target is GHG mitigation and enhancement of agricultural productivity in agricultural fields in Uganda. In fiscal year of 2021, we conducted 7 types of cultivation experiment in Tottori due to restriction of overseas travel by COVID-19. Tomato was chosen as simulative experimental plant, and urea was taken as nitrogen fertilizer. We tried to use rice husk biochar to moderate overdose of urea derive nitrogen in root environment of tomato. Several tomato rootstocks were tested to elucidate plant both growth potential and emission of nitrous oxide. We found the condition of tomato cultivation under adequate balance of base, utilization of rootstocks, use of urea and utilization of rice husk biochar. In this fiscal year, we started cultivating experiment from beginning of rainy season of last November. So far, the experiments were still on-going in Uganda. The research focus were following, 1. Evaluation of harvest yield for 2 types of vegetables under biochar application 2. Evaluation of reduction effect of greenhouse gas emission and soil carbon stock caused by biochar application 3. Estimation of N2O emission during vegetable cultivation period		

特定研究 3 Specific Research 3		対応教員 Corresponding Staff	石井　孝佳 Ishii, Takayoshi
研究代表者 Principal Researcher	岡本　龍史（東京都立大学理学研究科） Okamoto, Takashi (Graduate School of Science, Tokyo Metropolitan University)		
研究課題 Research Subject	C3-C4 細胞質置換受精卵の作出と発生 - 乾燥、高温耐性作物創生へ向けて Production and development of C3-C4 cytoplasm-substituted zygotes – for drought and heat tolerant crop improvement		
共同研究要旨 Summary of Joint Research	Hybridization has been recognized as having a decisive role in evolution and diversification of angiosperms. However, mechanism in hybridization largely remains open due to limitations in production of hybrid zygotes with desirable gamete combinations. In vitro fertilization (IVF) systems using isolated gametes have been utilized to examine fertilization events in maize, rice and wheat. In addition, IVF system promotes the access for mechanisms in hybridization and allopolyploidization using these three essential crops. In this study, we hybridized subfamily distant species of wheat and rice with IVF system. Hybrid zygotes from rice egg and wheat sperm cells ceased at multicellular embryo, and this hybrid incompatibility was overcome by the addition of wheat egg cell to the rice-wheat hybrid zygote. In reciprocal combination, fusion between wheat egg and rice sperm cell, the hybrid zygote did not divide, but doubling the dosage of rice sperm cell allowed hybrid zygotes to develop progressively. Notably, these proliferative hybrid zygotes developed to plantlets. FISH/GISH analyses indicated that rice chromosomes/genomes were mostly eliminated during early developmental stage of hybrid zygotes.		

⑵ 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	As we could not conduct the planned field survey due to travel restrictions caused by the COVID-19 and the political situations, we attempted to understand vegetation distribution and soil characteristics by analyzing vegetation and soil data obtained from the preliminary survey. In September 2019, three sites were selected in Guder village, Amhara Province from (1) free grazing (whole-year grazing) sites and (2) seasonal grazing sites, respectively, and several survey plots were established in each site and cover and plant height of emergent species were measured. Dry weights of the aboveground parts were also measured. Leaf nitrogen and phosphorus contents were measured for the several dominant species. Soil samples were also collected at each site and analyzed for total carbon, total nitrogen, available phosphate and potassium. The grazing pastures in the study area were dominated by perennials grasses such as *Sporobulos pyramidalis* and *Cynodon dactylon*. The vegetation survey confirmed the occurrence of 49 species, but both the number of species and diversity index were higher in the seasonal grazing sites. Leaf nitrogen contents were significantly higher in free graszing sites, suggesting that functional traits differed among pasture types. On the other hand, soil physicochemical properties did not differ significantly among pasture types. The results of the multidimensional scaling using the cover data showed that the plots in free grazing sites were placed on the negative side of axis 1 and those in seasonal grazing sites on the positive side, indicating that the species composition of the plant community was clearly differentiated by pasture type (Fig. 1). Biplots with environmental factors showed significant correlations ($p<0.05$) between axes 1 and 2, suggesting that axis 1 indicates pasture type and biomass, while axis 2 indicates diversity and leaf nitrogen content (Table 1). These results suggest that differences in grazing management type affect functional traits and functional diversity as well as biomass and species composition of pasture vegetation.		

重点研究 2 Focused Research 2		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	Because of the pandemic of Covid-19, not only overseas surveys but also domestic meetings were no longer possible, so we conducted the following research activities exclusively online. 1) Collection of Mongolian documents and literature We asked a researcher living in Mongolia to search for Mongolian documents related to wood use at the national archives and comprehensively convert them into word text. We also obtained news videos on forestry development and translated them into Japanese. In addition, we obtained literature on forestry and forestry science in order to write an article. 2) Comparing study of the famous drawing and old photographs of the city By getting high solution photograph of the famous painting of Ulaanbaatar drawn in the 1910s, we will able to make dramatic progress in our analysis and identify the locations where old photographs were taken. In particular, we were able to realize where and how determine the timber markets were in old Ulaanbaatar. 3) Confirmation of the timber harvesting situation using satellite images We were able to confirm our findings on timber harvesting throughout the country, especially in the suburbs of Ulaanbaatar, using satellite images, and wrote an article on the subject. 4) Comparison with photographs of the socialist era Photographs of the socialist era from the 1940s to the 1960s were newly obtained online and used to write a paper on urban construction and forestry promotion. 5) Editing the collection of papers In addition to presenting the results of the research described above at online research meetings, we also made presentations at the annual meeting of the Mongolian Studies Association of Japan, the Symposium of the Japanese Association for Desert Studies, and the occasion of Society for Grassland Archaeology, and edited and published them in a book.		

⑶ 一般研究 / General Research

一般研究 1 General Research 1		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 University)		
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 dry- and heat-tolerant crop, pearl millet.		
共同研究要旨 Summary of Joint Research	At the Graduate School of Agriculture, Kyoto University, seeds of IPno's 17956 pearl millet line, an inbred line, were treated with EMS, and the M1 lines were grown in the glass greenhouse. In addition, we produced 2000 heavy ion beam-treated mutants of the IPno's 17956 line. We evaluated the effect of different doses on phenotype at the ALRC. LET50 80Gy and LET150 40Gy suppressed plant growth. We also developed a genome-editing technique with intergeneric crossing between pearl millet and bread wheat. Wheat genome editing technology by intergeneric crossing conforms to the method developed in maize (Kelliher et al., 2019). At the ALRC, a GFP reporter gene was introduced into pearl millet pollen with particle bombardments and the transformation efficiency was evaluated. We also examined a method using magnetic beads and magnets to select pollen into which RNP was introduced. First, to find organic solvents for the magnet and magnet beads selection, we tested 13 organic solvents. Pollen tube elongations were observed in the pollens treated with xylene or dimethylformamide. Fresh pollen showed significantly more pollen tube elongation than dried pollens in the xylene-treated plot. To develop the method of stable pearl millet transformants, we examined the culture conditions for callus formation and redifferentiation from immature embryos at the Graduate School of Agriculture, Kyoto University. Stable callus proliferation was observed on a medium with a 2,4-D concentration of 2.0 mg L-1. Redifferentiation occurred on a medium containing 0.1 mg L-1 of		

	6-benzylaminopurine. We tried to identify a callus formation condition from mature seeds. Stable and high-quality callus tissues were obtained by removing embryos from mature seeds and culturing them in the MS medium containing 3% sucrose, 2,4-D and 6-benzylaminopurine.

一般研究 2 General Research 2		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 and clarifying how plants acquire nitrogen in nutrient-poor environments, such as arid lands where soil nutrients are limited, will provide important knowledge when considering the maintenance of arid land ecosystems. However, to determine the amount of inorganic nitrogen mainly absorbed by plants, equipment such as an autoanalyzer is required, and a more convenient method for determining the amount of inorganic nitrogen is needed. Therefore, in this study, we compared several extraction methods and concentration measurement methods for inorganic nitrogen that have been reported. As a result, the extraction efficiency of inorganic nitrogen differed depending on the type of solution used for extraction. Nitrate nitrogen had the highest concentration in the extractant when extracted with 2MKCl solution, and the concentrations were similar in the other extractants. The concentration of ammonia nitrogen was higher in the order of 0.5MK2SO4 > 0.5M NaCl > 2MKcl solution, and the maximum difference in concentration was three times. Even for the inorganic nitrogen measurement method, the characteristics of the results differed among the methods, necessitating improvements. We will continue our research on method improvement next year.		

一般研究 3 General Research 3		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	In 2021, field trial in a rainout shelter was conducted at Hokkaido University. Two tetraploid wheat varieties (Cham1 and ET23) were cultivated in two irrigation treatments (well-irrigated as control and restricted irrigation in the ripening period). In addition to the irrigation treatment, restriction of ear photosynthesis treatment was set by physically blocked the stomata on ear surface. Their drought performances, e.g., yield components as well as photosynthetic source functions for the grain development were evaluated. The major results obtained were below. 1. The drought treatment did not affect the grain yield. This could be because the high air temperature in rainout shelter in this year led to shorten the ripening period, which resulted in the grain yield reduction. The yield reduction by ear photosynthesis restriction was larger in Cham1, which indicates the ear photosynthesis could be more significant source for the grain yield in Cham1 compared to ET23. 2. The yield was significantly declined by ear photosynthesis restriction treatment. It could hamper the sink formation through the grain quantity development. The component analysis showed that the grain quantity reduction was resulted from decreasing the grains per ear. The ear photosynthesis restriction did not affect the canopy photosynthesis and LAI in the mid ripening stage. The SPAD at the flag as well as lower leaves at the 7 days after flowering was increased by the ear photosynthesis restriction. This indicates that the leaf photosynthesis could be compensated the		

	ear photosynthesis reduction. This compensation effects could maintain the entire canopy photosynthesis ability despite that the ear photosynthesis was blocked.

一般研究 4 General Research 4	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 (Research 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	Chinese wheat landrace “Hong-Mang-Mai” grown in Loss Plateau, China shows a high level of drought tolerance. Long and dense leaf hairs of this cultivar are considered to confer evaporation resistance from the leaves. Our previous studies demonstrated that long leaf hair of “Hong-Mang-Mai”is controlled by a single dominant on the short arm of wheat chromosome 7B. We attempted mapping of the *Hl2* gene and found a co-segregating microsatellite marker. Due to low polymorphism levels on 7BS chromosome arm “Hong-Mang-Mai”relative to “Chinese Spring”, no further markers were developed. Concurrently, we attempted a search for similar long hair mutants in barley, a distant relative but classified to the same tribe Triticeae. We identified a hairy peduncle mutant in our gamma-ray induced mutant panels. Barley hairy peduncle *(Hpn)* mutant exhibited a genetic segregation controlled by a single dominant gene, which was subsequently localized to a 2.4-cM interval on the short arm of barley chromosome 7H. Although tissues expressing long hairs differ between wheat and barley, i.e., leaves in *Hl2* wheat and peduncle in *Hpn* barley, their syntenic locations on the same homoeologous group could be due to orthologous genes. We anticipate initial cloning of the *Hpn* gene in barley may assist molecular cloning of the *Hl2* gene in wheat, which is an allohexaploid with three similar subgenomes (BBAADD).	

一般研究 5 General Research 5	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	乾燥地でも生育できる作物の開発を目指して：ストレス特異的な根細胞内構造の解析 The analysis of the stress induced cellular compartments aiming to generate the super crop for drylands	
共同研究要旨 Summary of Joint Research	Response against iron (Fe) deficiency in 46 kinds of *Aegilops tauschii* was analyzed. Fe deficiency caused leaf Chlorosis because of a decrease in chlorophyll contents. Chlorophyll contents of 46 kinds of *Ae. tauschii* by SPAD (Soil & Plant Analyzer Development) value and it was shown that there were differences among 46 kinds of Fe deficient *Ae. Tauschii.* Chlorophyll contents influence the rate of photosynthesis. Therefore, it was suggested that there is genetic difference involved in photosynthesis among 46 kinds of *Ae. tauschii.* To analyze further the response to Fe deficiency in *Ae. tauschii,* the concentration of deoxymugineic acids (DMA) in the root washes, phenolic compounds in the roots and the essential micronutrients in the leaves were analyzed. Phenolic compounds were reported to be involved in Fe acquisition from roots and translocation in the plant body. It was shown that the roots of *Ae. tauschii* accumulated cinnamic acid, caffeic acid, coumatic acid, ferulic acid and benzoic acid, and their concentration were different among 46 kinds of *Ae. tauschii.* Principal component analysis showed that SPAD values were positively correlated with Fe concentration in leaves, while it was negatively correlated with DMA concentration from the roots. The copper (Cu), Zinc (Zn) and Manganese (Mn) concentrations in leaves were positively correlated strongly. Fe also positively correlated with Cu, Zn and Mn. Genome-wide association study (GWAS) showed that there are several genomic markers which were suggested to be involved in SPAD values, phenolic compounds, DMA and metal concentrations.	

一般研究 6 General Research 6	対応教員 Corresponding Staff	谷口　武士 Taniguchi, Takeshi
研究代表者 Principal Researcher	片岡　良太（山梨大大学院総合研究部生命環境学域） 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	The arid regions in the world are getting to expand. Increasing water stress makes dryland agriculture difficult, but in such areas, it is necessary to expand irrigation facilities, however, water sources are limited and costly in those area. Therefore, it is difficult to maintain dryland farming without improving the water stress tolerance of plants. This year, lettuce was grown in a water stress control media supplemented with PEG8000 in order to get the information of T-2 strain which isolated from barley root as endophytic fungus. The water potential with the addition of PEG is calculated by Eq (Burlyn E. Michel, 1983) (1). Ψ (MPa) = 1/10 (1.29 x [PEG] 2 x T-140 x [PEG] 2-4.0 [PEG]) (1) [PEG]: PEG concentration (0 ~ 0.8g / H2O) T: 5 ~ 40 The water potential was reduced to -0.511 MPa at PEG 20%. These water potentials show the water stress close to the maximum water volume (0MPa), growth inhibition water point (-0.1MPa), and initial wilting point (-0.61MPa), respectively. Infection of the endophytic fungus strain T-2 with plants improved the plant growth under water stress conditions, and improved the plant growth even at the water potential where growth inhibition would normally occur. When the above-ground part and root length, freshness and dry weight were measured as growth parameters, the above-ground part and root length and fresh weight significantly increased due to infection with the endophytic fungus strain T-2 under water stress conditions. It is known that the dry weight of plants under water stress conditions increases the ratio of roots to the above-ground part, but in this study, the ratio of roots decreased with the magnitude of water stress. However, when infected with the endophytic fungus strain T-2 at any PEG concentration, the plant length increased and the root ratio increased up to PEG 10%. In the case of PEG15%, plant size was more increase than control plants by infection with the endophytic fungus strain T-2, even though the above-ground/root ratio was almost similar with and without the endophytic fungus strain T-2. It is summarized as follows, these results were clarified that the endophytic fungus strain T-2 promoted host plant growth, especially root elongation. This results suggested that the promotion of root elongation and growth increased the root surface area and improves the water acquisition capacity of plants.

一般研究 7 General Research 7	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	Because the sap flux measurement system is different in the structure and the accuracy (resolution) of the sensors and the data logger that receives the signal from the sensor, we examined whether the system based on external heat ratio method (HRM) sensors successfully capture the variable sap flux using the intact grass individuals and the excised branches. We covered the sensors from solar radiation and the ambient air that could cause serious noises on the measured sap flux, which depends on the heat transfer from the sensor via xylem. Measured sap flux via sap flux sensors exhibited good accordance with the gravimetrically measured water uptake by excised branches, suggesting the reliability of our sap flux monitoring system. IN the field, measured sap flux exhibited serious noises under sunny conditions, but by adding correction equation in the computation of sap flux together with additional measurements of the surrounding stem temperature, measured sap flux exhibited strong relationship to the solar radiation and vapor pressure deficit, suggesting that the sap flux measurement system (and the insulators) together with the correction methods were useful for monitoring of sap flux under variable light and temperature environments, which are not suitable for using external HRM sensors by previous studies. We have prepared for the monitoring of sap flux in the Loess plateau sites by our collaborative researchers in China.	

一般研究 8 General Research 8	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	To reveal the effects of nano particle silicon (NP_Si) application on mineral contents in sorghum (*Sorghum bicolor* cv. K8) grains, we cultivated the sorghum under drought stress conditions with or without NP_Si treatments. Dry matter weights of leaves, stems, spikelets and grains were significantly lower in the drought stress treatments. However, no effect of NP_Si on those was observed, which is similar to the results of silicate treatment we obtained last year. On the other hand, Fe and Zn contents in grains were increased by NP_Si treatment under drought stress conditions. Therefore, effect of NP_Si on the plant biomass and mineral contents in grains was similar to that of silicate under our experiment conditions. Furthermore, involvement of NP_Si in iron transport and its alleviation of stress were analyzed. We focused on the induction of iron transport-related genes under iron deficiency conditions. Transcription of *SbNAS3*, which is thought to be one of the enzymes in the biosynthetic pathway of nicotianamine involved in iron transport *in vivo*, in leaves was markedly increased on the third day of iron deprivation treatment, but its transcription was suppressed by NP_Si treatment and also on the fifth day. As mentioned in the previous project report, silicate treatment suppressed transcription of *SbNAS3*. Thus, it suggested that NP_Si treatment, like silicate treatment, also alleviates the iron deficiency response and is involved in iron transport *in vivo*.

一般研究 9 General Research 9	対応教員 Corresponding Staff	藤巻　晴行 Fujimaki, Haruyuki
研究代表者 Principal Researcher	坂口　敦（山口大学大学院創成科学研究科） 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	Due to the unusual weather in August of 2021, we couldn't impose water stress to soybeans. We couldn't find out the best equation to estimate the value of CWSI, however, we succeeded to observe the leaf temperature using Drone, and found that the soil temperature of furrow doesn't affect to the estimation of CWSI using the thermal image of a given soybean field if the thermal image is taken after the monsoon season. The equation of CWSI-T includes the soil heat flux (G) in it, and the soil heat flux is usually estimated using the ratio of soil heat flux to the net radiation (Rn). By the observation of them, we found that the ratio of G/Rn at our study field was 6.2% on average on sunny days in August and which standard deviation was 0.023. We also succeeded to figure out the value of water stress index from stomatal conductance without the soybean field under non-water stress condition. Using this method that we developed, we could estimate the value of water stress index at R2 = 0.85 by the observation of stomatal conductance at general soybean field under water stressed condition.	

一般研究 10 General Research 10	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 this fiscal year, we improved the estimation of Asian dust emission frequency, and clarified that this improvement has a significant impact on the estimation of Asian dust transport processes to the North Pacific and Arctic regions and aerosol-radiation-cloud interactions. We improved the observational reproducibility of Asian dust emission frequency (number of days of dust emissions per season) by introducing information on the threshold friction velocity based on satellite observations (arid-region maps) into our global aerosol model. This improvement led to a larger seasonal variation in Asian dust emissions, increasing dust emissions during spring and decreasing dust emissions during summer. The increased emissions in spring enabled more efficient transport of Asian dust to the North Pacific and Arctic regions, and the annual mean atmospheric loading of Asian dust	

	increased by 43% in the North Pacific and 130% in the Arctic. The annual mean deposition flux of Asian dust increased by 49% in the North Pacific and 73% in the Arctic. These results indicate that the treatment of threshold friction velocity in numerical models is important for estimating the deposition of Asian dust to the snow/ice surface and open ocean and the resulting interactions with cryosphere and marine ecosystems. Changes in the atmospheric loading of Asian dust also changed the light scattering and absorption of aerosols and the number concentrations of cloud condensation nuclei and ice nuclei particles, affecting the estimation of aerosol-radiation and aerosol-cloud interactions mainly near the emission sources. These findings were published by Scientific Online Letters on the Atmosphere.

一般研究 11 General Research 11		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 Agricuture, 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	To investigate the characteristic of wind speed fluctuation around the inclined flat plates which were modeled the solar panels, wind tunnel tests were carried out using a uniform wind tunnel (outlet size: 0.2m × 0.2m). The tilted flat plates were set as a 1/100 scale of solar panels. The inflow wind speed was set to 12 m/s, and the tilt angle of the flat plate (θ = 10 °, 20 °, 30 °) and the row number of the plates (1 to 5 rows) were set at measuring part. The wind speed was measured at 1 cm intervals in the vertical and horizontal directions using a hot-wire anemometer in a downstream range of about 10 times the tilt height. The following results were mainly obtained from the experiments. ・It was obtained the wind speed on the back of the inclined flat plates in each experiments decreased from 70% to 80%. It was considered that this was due to the generation of flow separation at the first flat plate on the upstream side. It was confirmed that the wind speed gradually recovered to the initial inflow wind speed behind a distance range of about 10 times the width of the inclined plate of 20 mm. ・It was shown that the larger the angle of the inclined flat plate, the longer the distance for the wind speed behind the flat plate to recover to the inflow wind speed. ・It was obtained the proportion of wind speed increase near top side of the plates gained with the increase of the angle of inclined plate. The proportion of wind speed increase was up to 15% in case of θ = 30°and 5 rows of the plates.		

一般研究 12 General Research 12		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科） 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 2021, a process-based model of soil nitrogen dynamics developed at the University of New Hampshire for simulating greenhouse gas (e.g., N_2O, CH_4) emissions from soil was used as a model to evaluate the relationship between crop nitrogen uptake and growing season weather conditions. The DNDC model has few examples of application to Japanese farmland, and its feasibility needs to be verified. In this study, we examined the feasibility of using the model for a sweet potato field cultivated at the Matsudo campus of Chiba University. In this model, leaf area index (LAI) and nitrogen uptake by the crop are proportional, and evaluating the accuracy of LAI simulations is essential for discussing nitrogen uptake. However, it is difficult to obtain accurate continuous data non-destructively for LAI. Therefore, in this study, we attempted to estimate LAI using the Normalized Vegetation Index (NDVI) obtained by drone sensing. DJI P4 Multispectral equipped with a multispectral camera was used in this study. The LAI was estimated with an RMSE accuracy of 0.31 despite an observation time of approximately 1 minute. Comparison of the continuous data of LAI estimated by the drone with the simulation results of DNDC showed that the simulation underestimated the LAI after 50 days from planting, although the trend was similar. In this study, many default parameters of the model were used for model testing.		

	Therefore, there is room to improve the accuracy of the simulation by adjusting the parameters.

一般研究 13 General Research 13		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	We tried to cultivate tropical fruit trees by applying water harvesting system in Shizuoka region. Devastated tea plantation was developed and installed a rainfall collection sheet on a slope, and buried a large pot of avocado and guava in the lower part, and tested an energy-independent self-collection cultivation method. The solenoid valve was automatically controlled based on soil moisture in the pot and irrigated with a dripper. Amount of irrigation could be obtained by water harvesting mainly and the growth of avocado and guava were well. Cultivation experiments were conducted with the average soil water content in the pot as 20% at the start of irrigation, but in late July, the water content in the pot remained high at 29% due to rainfall. In avocado, the relationship between saturation vapor deficit and sap flow velocity was unilaterally and downwardly distributed over time. Considering the summer when the relationship between the two is uniquely determined, the average value of soil water content was divided into two at 23%. The average of these numbers was 26% for the high and 20% for the low. In addition, even in the state of 20%, which is the irrigation index, the actual soil water distribution was as high as 30% or more in the surface layer and 8% in the lower layer. This condition led to a slow-down. It was found that there is a high possibility of causing water stress when only the soil water content of the surface layer is used as an index of irrigation, especially when the saturation is high. On the other hand, guava is standing, and it was difficult to verify that it was applied to avocado because the stem to which sap flow measurement was applied did not represent the entire tree.		

一般研究 14 General Research 14		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 abberrations in the chromosome of bread wheat either gametophytically or zygotically. 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 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 took advantages of 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 2021, we have conducted the following researchs; (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 15 General Research 15	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	The following three points were conducted in FYR3. (1) Continuous observation of size-segregated aerosol concentrations at roof top of the ALRC buiding was continued after major maintenance of the equipment (PM712). Atmospheric aerosol particles are 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. (2) The PTFE tape filter samples were chemically analyzed at the Lab in Nagoya University. Long term size-segregated ionic composition data are valuable data for studying source-receptor relationship of pollutants in East Asia. 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. (3) 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 2020. The samples were tested for the reagent thin film method to show the presence of nitrate or ammonium. The proportion of particles containing nitrate and ammonium in the coarse particles were correlated well with the bulk chemical analysis. 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 16 General Research 16	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	We searched for 4 kinds of symbiotic fungus in UPM (Universiti Putra Malaysia), and tried to verify the symbiotic effect on Arabidopsis thaliana. Infection experiments were performed to confirm growth promotion under oligotrophic conditions. In the soil, infection experiments were performed on Arabidopsis thaliana. After growing Arabidopsis thaliana under sterile conditions for 7 days, it was grown in soil mixed with each bacterial suspension for 2 weeks. For the soil, black soil containing a lot of nutrients and sand containing no nutrients were used to reproduce the oligotrophic conditions. We performed under three conditions: black soil only, sand and black soil, and sand only. Six measurement methods were used: the length of the above-ground part, the length of the root, the number of leaves, the amount of chlorophyll, the surface area, and the survival rate. As a result, we were able to confirm the most growth promotion in Aspergillus niger (A.niger). Next, infection experiments were performed on MS medium (Murashige and Skoog) instead of soil. By adding a concentration gradient to the bacterial turbid solution to be mixed with the medium, the concentration of the bacterial bacteria showing the most growth promotion was searched for. The concentration of the bacterium was compared with 102spores/100ml, 104spores/100ml, 106spores/100ml. Arabidopsis was grown for 10 days and an infection experiment was conducted for 2 weeks. All the plants infected with the fungus were larger than the plants not infected with the fungus. From the above, we were able to find the growth promoting effect of A. niger.	

一般研究 17 General Research 17	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	Understanding the physiological and ecological characteristics of halophytes and their relationship to habitat environmental conditions is necessary to predict the response of dryland grassland ecosystems distributed between the Aral and Caspian Seas to climate change. Carbon stable isotope ratio ($\delta^{13}C$) of leaves reflects the intrinsic water use efficiency (ratio of photosynthesis rate to stomatal conductance) in C3 plants, while oxygen stable isotope ratio ($\delta^{18}O$) of leaves reflects transpiration and the $\delta^{18}O$ of water source regardless of photosynthetic type. Therefore, it is expected that $\delta^{13}C$ and $\delta^{18}O$ of leaves can be used as indicators to evaluate drought and salt tolerance in halophytes. However, the information on $\delta^{18}O$ in halophytes is still lacking. Since we were unable to visit Uzbekistan and Russia in FY2021 due to the COVID-19 expansion, we first measured the $\delta^{13}C$ of 71 species (312 individuals) of dried leaves of halophytes collected in 2010 at three sites around the Aral Sea, and the $\delta^{18}O$ of 40 species (200 individuals) of them. Then, to clarify the determinants of $\delta^{18}O$ of halophyte leaves in this area, the effects of physiological and ecological factors such as photosynthetic type (C3/C4), plant type (annual herb/ perennial herb/ shrub or tree), root depth (0.2-3m/ 3-16m) and climatic factors such as annual precipitation and annual mean temperature were investigated using multiple regression analysis. The results showed that $\delta^{18}O$ of halophyte leaves in this area were significantly affected by photosynthetic type, plant type, annual precipitation, and annual mean temperature, whereas they were not affected by root depth (water source). Furthermore, when $\delta^{13}C$ of leaves was added as a physiological and ecological factor, $\delta^{18}O$ of leaves of C3 halophytes were significantly positively affected by $\delta^{13}C$, plant type, and annual mean temperature, and significantly negatively affected by annual precipitation. C3 individuals with higher intrinsic water use efficiency under low precipitation and high temperature had higher $\delta^{18}O$, suggesting that C3 individuals with higher $\delta^{18}O$ may have higher stomatal conductance. On the other hand, C4 species were significantly affected only by $\delta^{13}C$ and plant type, with the latter having a greater effect.

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	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 Effect of near surface air turbulent on mass and heat exchange between soil and atmosphere	
共同研究要旨 Summary of Joint Research	The objective of this project is to develop a numerical model for predicting water evaporation from ground surfaces that can take into account variations in ground surface irregularities and mass transfer characteristics. In FY2021, in order to clarify the long-term variation in the effects of topographical conditions of agricultural land surfaces, such as ridges, on water vapor and heat exchange with the atmosphere and on the distribution of moisture and temperature in the soil profile, temperature and soil water content monitoring was initiated. A 5 m long ridge was constructed in the east-west direction, and dielectric constant soil moisture sensors, soil water potential sensors, and thermocouples were buried at given locations. Calibration of the anemometer is currently underway to measure air turbulence at the ground surface using a three-dimensional ultrasonic anemometer. In order to account for the effects of topography, vegetation and structures on the land surface, and the three-dimensional movement of mass and heat, it is essential to construct an integrated model that combines an air flow model coupled with water vapor and heat transport in soils. The model for soil liquid water, water vapor, and heat transport is based on the general-purpose model HYDRUS. We have modified HYDRUS to allow for accounting ridge-like ground surface geometry.	

一般研究 19 General Research 19	対応教員 Corresponding Staff	山中　典和 Yamanaka, Norikazu
研究代表者 Principal Researcher	三木　直子（岡山大学学術研究院環境生命科学学域） Miki, H. Naoko (Faculty of Environmental and Life Science, Okayama University)	

研究課題 Research Subject	マツ属種の水分生理的形質の地理的変異 Geographical variation of water physiological traits of *Pinus* species
共同研究要旨 Summary of Joint Research	Traits of tree are influenced by genotype and growing environment. In this study, we conducted provenance experiment at two planting sites (Iwate and Tottori), and clarified the effects of provenance and planting site on physiological and ecological traits of Japanese red pine (*Pinus densiflora*), considering plasticity. Five to six-year old individuals (three years old after planting) derived from seed of the later generations of *P. densiflora* collected from natural population mother trees from 10 provenances in Japan were used. As physiological and ecological traits, tree height and ground diameter, leaf area, leaf dry weight, dry weight per unit leaf area (LMA), and leaf nitrogen content were measured. The results showed that individuals from colder provenance tended to have higher leaf nitrogen content and those from sunnier provenance tended to have larger leaf size. Since the leaf nitrogen content is closely related to photosynthetic capacity, individuals from colder provenance are considered to have higher photosynthetic capacity and higher productivity. Also, individuals from sunnier provenance may have larger leaves and higher productivity. The high productivity may have resulted in the amount of growth in individuals from colder and sunnier provenance. Leaf area and tree height growth were greater in Iwate among the planting sites. Since it has been reported that leaf elongation growth is greater with longer daylength in *P. densiflora*, the greater leaf area and growth may have been caused by the greater sunlight in Iwate. Differences in traits between the two planting sites were greater for individuals from colder growing areas in LMA and tree height growth. It has been reported that individuals with greater plasticity can grow well in various environments. It was suggested that low plasticity of traits in warmer provenances may be associated with reduced growth when *P. densiflora* from southern provenances were transplanted to the north.

一般研究 20 General Research 20	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	The mangroves in the coastal areas of the Kutch region have been lost due to the development of salt fields in the coastal areas and have been disturbed by natural disasters such as cyclones and earthquakes. In order to use mangrove ecosystems while maintaining the sustainability of ecosystem services, it is necessary to accumulate knowledge on the dynamics of these mangrove forests and their response to environmental changes. To collect this information, Landsat5, 7&8 satellite images of the area were analyzed for the following three questions: 1) Long-term changes in biomass of mangrove forests in the area; 2) How drought and drought conditions affect biomass; and 3) How mangrove forests have been affected by development and other factors during the period. Where are environmental factors causing expansion or contraction? Variations in NDVI calculated from multispectral images of Landsat5, 7 and 8 from 1988 to 2019 suggest that leaf biomass of mangroves in the area have increased in the long term up to the present. However, NDVI was not monotonically increasing, but was decreasing from the late 1990s to the early 2000s. This is most likely due mainly to increased water stress caused by the continuous occurrence of drought from the late 1990s to the early 2000s. The fact that no significant changes in NDVI were observed after a single year of drought suggests that mangrove forests have a certain level of resilience to drought. The NDVI of mangroves in the area was found to be monotonically decreasing during the dry season and increasing with the onset of the rainy season. Comparison of land cover maps revealed that the main reasons for the decline of mangrove forests are the erosion of sandy soil due to tides and the conversion of land use due to development of coastal areas. On the other hand, some mangrove forests were observed to be expanding their growth area in areas that were not significantly affected by tides. Overall, the increase and decrease in mangrove area was almost the same. The data from this study will be useful in monitoring the response of mangrove forests in the area to future environmental changes.	

一般研究 21 General Research 21	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 Engineering, 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. Especially, we focus on the light environment in a greenhouse. For better quality and faster cultivation, various vinyl films have been researched and commercialized to control the light environment inside the greenhouse. In 2021, results of our research have been reported as follows, ・The optical fiber multipoint light receiving system, which has 16-channel, has been constructed (Fig. 1). ・Utilizing a growth chamber in Arid Land Research Center in Tottori University, a correlation between light intensity and growth result under an actual condition(light, and temperature) has been evaluated. ①Four kinds of optic films have used, and light intensity at a different angle has been measured (Fig. 2). As a result, it was possible to quantitatively evaluate that the light intensity from the horizontal direction is higher than that of the transparent film. ②Dry weight of *Eustoma russellianum* at different optic film has been measured and evaluated (Fig. 3). As a result, it was difficult to make a clear correlation between a raising of *Eustoma russellianum* and the agricultural films. Next step, we will continue to measure the dry weight of the young *Eustoma russellianum* and evaluate the correlation between light intensity and growth result.

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	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	半乾燥地における在来種ナラ林と外来種ニセアカシア植林地における土壌微生物の共起ネットワーク構造 Co-occurrence networks of soil microbes in exotic black locust plantations and native oak forests in semi-arid area.	
共同研究要旨 Summary of Joint Research	The original aim of this study is to clarify the co-occurrence network relationships among soil microbes in native oak forests and exotic black locust plantations, in Loess Plateau, China and to elucidate the effects of environmental factors such as vegetation type and precipitation on the co-occurrence pattern of microbes. Specifically, we planned to collect soil samples from black locust plantations and oak forests along the precipitation gradient in the Loess Plateau. We also planned to determine the community composition of soil fungi and prokaryotes using NGS, and to clarify the co-occurrence network structure among soil microbial species. The study initially focuses on black locust plantations and natural oak forests, which are widely distributed in the Loess Plateau of China. We planned to collect soil samples from both types of forests and extract soil DNA for determining the community composition by amplicon sequencing for the 16S rRNA gene and ITS region using NGS. And we also planned to perform a co-occurrence network analysis of the dominant OTUs. In FY2021, because of the pandemic of COVID-19, we, unfortunately, could not conduct the planned sampling. Instead, we analyzed our previous soil samples of the reciprocal transplant incubation conducted in black locust plantations, in Loess Plateau. In the study, we conducted a reciprocal transplant incubation study along with precipitation gradient in Loess Plateau, China, with analyses of microbial community structures and co-occurrence network. By the analyses, we found that microbial assembly was strongly affected their soil origin where soils collected. And the impact of environmental factors at the incubation site had only a small effect on the microbial communities.	

一般研究 23 General Research 23	対応教員 Corresponding Staff	黒崎　泰典 Kurosaki, Yasunori
研究代表者 Principal Researcher	福本　侑（大阪市立大学理学研究科） Fukumoto, Yu (Graduate School of Science, Osaka City Univresity)	

研究課題 Research Subject	モンゴル北部における湖沼環境と気候・風成塵の長期的変動の復元 The long-term fluctuations of lake environment, climate and aeolian dusts in Northern Mongolia
共同研究要旨 Summary of Joint Research	Diatom and pollen fossil assemblages were analyzed on 2.5m long core sediment from Lake Ulaan Burgas, Northern Mongolia for reconstructing climate and environmental changes of the late Holocene period. Radiocarbon dating of 5 samples showed that the core represents last 3.2 thousand years of sedimentation. Diatom flora was dominated by benthic taxa mainly Fragilarioid complexes (Genus Staurosira, Staurosirella, Pseudostaurosira), and a planktonic taxon of Stephanodiscus minutulus. 5 stratigraphic zones were identified based on the changes in relative amount of these dominant taxa. Pollen flora was represented by Pinus, Betula, Artemisia and Cyperaceae, and their community change was rather synchronous with diatom floral changes. Climate before 2.8 cal ky BP was inferred as relatively dry, but the increase of planktonic taxa and wet indicator pollens, and lithological changes implied wet condition from 2.8 cal ky BP. Wetter climate from this period was commonly observed in previous paleoenvironmental studies in Mongolia, and might have affected prehistoric periodization from bronze age to iron age. At 2.0-1.6 cal ky BP, temporal lake level drop was implied by the replacement of planktonic taxa by benthic taxa, and decrease of taiga forest pollens. Appearance of many epiphytic taxa at 1.6-0.8 cal ky BP indicated relatively stable climate seasonality, but temporal higher lake level was observed at 1.1-0.8 cal ky BP. The most recent period from 0.8 cal ky BP was characterized by the appearance of Staurosira incerta although its environmental implication is yet unknown. Further diatom ecological research and precise analyses are needed to make clear more accurate environmental changes.

一般研究 24 General Research 24	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	フーリエ変換赤外分光法による乾燥地植物のフィールド代謝動態の解析 FT-IR-based metabolic profiling of arid land plants in the field condition	
共同研究要旨 Summary of Joint Research	Fourier transform infrared (FTIR) spectroscopy is one of the major techonologies for profiling molecular structure and their changes in the biomass. FTIR has an advantage for analyzing supramolecular compounds. Wheat (*Triticum aestivum* L.) is known to be negatively affected by heat stress, and its production is threatened by global warming, particularly in arid regions. Thus, efforts to better understand the molecular responses of wheat to heat stress are required. In the present study, Fourier transform infrared (FTIR) spectroscopy, coupled with chemometrics, was applied to develop a protocol that monitors chemical changes in common wheat under heat stress. Wheat plants at the three-leaf stage were subjected to heat stress at a 42 ◦C daily maximum temperature for 3 days, and this led to delayed growth in comparison to that of the control. Measurement of FTIR spectra and their principal component analysis showed partially overlapping features between heat-stressed and control leaves. In contrast, supervised machine learning through linear discriminant analysis (LDA) of the spectra demonstrated clear discrimination of heat-stressed leaves from the controls. Analysis of LDA loading suggested that several wavenumbers in the fingerprinting region (400–1800 cm−1) contributed significantly to their discrimination. Novel spectrum-based biomarkers were developed using these discriminative wavenumbers that enabled the successful diagnosis of heat-stressed leaves. Overall, these observations demonstrate the versatility of FTIR-based chemical fingerprints for use in heat-stress profiling in wheat.	

一般研究 25 General Research 25	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	野生タルホコムギを利用した耐乾性コムギ育種のための分子遺伝学的解析 Molecular genetic analysis for wheat breeding of drought tolerance using wild Aegilops tauschii	
共同研究要旨 Summary of Joint Research	The expansion of arid lands has led to a worldwide need to breed drought-tolerant wheat. However, genetic diversity of wheat is poor compared to other major crops, and it is a major barrier to modern wheat breeding. To overcome this defect, Prof. Tsujimoto has been 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. To determine the loci controlling ABA sensitivity in the chromosome regions, F3 population of Norin61 and major ABA-hypersensitive line named as Oka28 has obtained. Among 364 individual F3 lines, 40 lines were possessed ABA-hypersensitive traits. These lines, together with 20 lines showing low ABA sensitivity from the F3 populations, were analyzed by next-generation sequencing to identify QTL related to ABA sensitivity using GRAS-Di technology. As the result, major QTLs associated with ABA sensitivity were detected in the short arm of chromosome 5A (5AS) and the short arm of chromosome 2A (2AS). In addition, other QTLs were also detected in the long arm of chromosome 1D (1DL), the long arm of chromosome 2B (2BL), the long arm of chromosome 3A (3AL), and the long arm of chromosome 5A (5AL). Since the MSD population have abundant genetic diversity in the D genome, most of the QTLs were thought to be detected in the D genome. However, surprisingly the detected QTLs were prominent in the A and B genomic regions. The genomes of A and B are derived from the durum wheat Langdon used in the primary synthetic wheat. Therefore, a comparison of primary synthetic wheat and Norin61 can reveal whether ABA-hypersensitivity was the result of the accumulation of specific genomic fragments from Langdon.

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	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	砂丘地での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育特性評価 Evaluation on growth characteristics of Allium bioresources under environmental stress in arid field	
共同研究要旨 Summary of Joint Research	In previous study, we have been able to obtain growth characteristics of *Allium* bioresources during conventional summer cultivation. In this study, *Allium* bioresources were cultivated on sand dunes, and the growth characteristics of the resources were evaluated. 1) Summer dryland cultivation trial of *Allium* bioresources: In the end of May 2021, two lines of *Allium* relatives species (*A.roylei* and *A.vavilovii*), two Japanese bunching onion (*Allium fistulosum* L.) cultivars‘Kujo 4-2’ (genome composition: 2n=16,FF) and ‘Nagasaki zairai’, eight Shallot chromosomes addition lines (genomic composition: 2n=17,FF+1A-8A), one line of *A. fistulosum -A.vavilovii* allotriploid, 3 lines of *A. fistulosum*-shallot allotriploids (2n=24,FFA), *A.galunthum-A.fistulosum* and amphidiploid (2n=32,GGFF), a total of 16 cultivars or lines were planted in the Arid Land Research Center. Three to five seedlings each were planted in a greenhouse. After harvesting these materials on September 26, morphological characteristics (plant height, leaf blade length, lower leaf sheath length, plant weight, single plant weight, and number of divisions), were determined. In addition, Chlorophyll content (chlorophyll-*a*, chlorophyll-*b* and carotenoids) and soluble carbohydrate (fructan) content in leaf sheath were investigated. Growth characteristics tended to be lower than under conventional cultivation, but several lines (FF+1A, +6A, FFA, and FFV) showed growth characteristics comparable to those under conventional cultivation. In terms of fructan content, several lines showed a significant decrease in fructan content compared to conventional cultivation. Confirmation of sugar composition by thin layer chromatography showed the disappearance of oligo saccharide spots in FF+1A, +6A and +7A. This result indicates that these lines may be adapting to drought stress by altering their in vivo sugar composition. 2) Winter dryland cultivation test of garlic bioresources: Twenty-four lines of garlic bioresources, including lines adapted to sand dune sites, discovered in this joint research project in 2013, were cultivated in dryland during the winter season. After growing in the dune test plots from October 2021 to May of the following year, 102 metabolite profiling data in the bulb and root portion were obtained by LC/MS analysis to evaluate the characteristics of the dune-adapted lines. The principal component analysis based on the metabolite in both organs showed that the dune-adapted lines were plotted at a distance from the other lines. This result indicate that the dune-adapted lines have different metabolite profiling from the other lines, and the possibility of finding metabolites that may be related to environmental stresses in winter garlic cultivation.	

一般研究 27 General Research 27	対応教員 Corresponding Staff	山中　典和 Yamanaka, Norikazu

研究代表者 Principal Researcher	篠田　雅人（名古屋大学大学院環境学研究科） Shinoda, Masato (Graduate School of Environmental Studies, Nagoya University)
研究課題 Research Subject	新しい干ばつ感受・回復指標を用いた植生脆弱性の評価 Vegetation vulnerability as revealed by novel drought sensitivity and resilience indices
共同研究要旨 Summary of Joint Research	This study is aimed (1) to evaluate detailed responses of vegetation (NDVI) of the non-resilient area in northwestern Mongolia to droughts during 1999-2002 at a higher resolution (0.1 grid), and (2) to assess changes in the vulnerability by comparing two drought periods (1999-2002 and 2007-2009), using novel drought sensitivity and resilience indices. These issues were addressed in the previous year (2020), while the vegetation vulnerability was assessed using ground-based plant species data this year (2021). Drought sensitivity (SI) is defined as vegetation response to decreased precipitation from pre-drought to drought phases, and resilience (RI) is defined as response to increased precipitation from drought to post-drought phases. Vulnerability vectors were created by combining SI and RI. Additionally, livestock data at the county (soum) level was used to estimate grazing impacts on vegetation vulnerability. Results showed that there was a large difference in vegetation recovery among regions after the drought periods of 1999-2002 and 2007-2009. As for the 1999-2002 drought, vulnerable grids were observed in the southern desert and steppe areas as a whole, while non-vulnerable in the north. In addition, it was found that the overall degree of recovery after 2007-2009 was lower than after 1999-2002. Furthermore, we investigated the change in livestock number during the 2007-2009 drought and its impact on vegetation vulnerability. There was a tendency for NDVI recovery to increase in areas where livestock number began to decline earlier. The large post-drought recovery of biomass in the steppe region is explained by the interannual change of plant species composition (i.e., the earlier recovery of annuals compared with perennials).

一般研究 28 General Research 28	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	樹木の有用樹脂生産における植物ホルモンの役割 Effects of plant hormones on gum/resin production in trees	
共同研究要旨 Summary of Joint Research	To establish sustainable management of frankincense trees in the drylands of Oman, the roles of ethylene (Et), jasmonic acid (JA), and salicylic acid (SA) and their interactions in frankincense resin production in Boswellia sacra trees were studied. We conducted a preliminary experiment on domestic cypress species, such as the types of treated substances, treatment methods, and concentration settings. The experiment was carried out on *Chamaecyparis obtuse*, *Thujopsis dolabrata*, *Cryptomeria japonica* and *Metasequoia glyptostroboides* saplings in a nursery of SFC, Tottori University. Various lanolin pastes containing Ethrel, methyl jasmonate, sodium salicylate and combinations of these compounds were applied to debarked wounds on the trunks. After a certain period of treatments, the resin secretion and anatomical characteristics were also studied. The effects of plant hormone treatments varied with species, but constant effects were observed. A part of obtained results was analyzed and reported (see Publication list 1). Trees of *B. sacra* with multiple trunks were selected at the Agricultural Experiment Station, Sultan Qaboos University, Oman. The paste application and evaluation of resinous characteristics was carried out as above. The combination of Ethrel and methyl jasmonate greatly enhanced frankincense resin production within 7 days in both seasons. The application of JA alone, SA alone or a combination of both did not affect resin production. These findings suggest a high possibility of artificial enhancement of frankincense resin production by the combined application of Et and JA to B. sacra trees. The results were analyzed and reported (see Publication list 2).	

一般研究 29 General Research 29	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	There is concern about the health effects of Asian dust (mineral dust) originating in arid areas such as the Gobi Desert and the TaklaMakan Desert. The purpose of this research is to conduct a health impact survey of residents in Mongolia who are likely to be exposed to high concentrations of Asian dust, and to contribute to the improvement of the quality of daily life based on the knowledge obtained. The research areas selected for this study were Ulaan Bataar and Zamin Uud (National Agency Meteorology and the Environmental Monitoring), where LIDAR systems are installed and which are jointly managed by the the Ministry of the Environment of Japan and NAMEM, and Mrun, where a meteorological observatory is located. The survey was conducted as much as possible, considering the COVID-19 pandemic, with three seasons in mind: Season 1 around October (when air pollution starts), Season 2 around January (when air pollution is severe), and Season 3 around April (when Asian dust occurs). In the questionnaire survey, the following were investigated: Subjective symptom (Nose, eyes, respiratory organs, skin, fever, headache, stress) prevention action and going out situation of the self-writing system of WEB media or paper media. For most of the participants, Since the questionnaire survey was not suitable, it was conducted in paper media. The questionnaire survey was conducted from October 2018 to October 2021. The total number of participants was 356. The CART model was used to analyze the relationship between symptoms and environmental factors. In the analysis adjusted for sex and age, significant strong relationship between Asian dust and the following symptoms was found. Nose (P = 0.001), respiratory (P = 0.002), throat (P = 0.022), skin symptoms (Exposed: P = 0.004, Coated: 0.045), and headache (P = 0.002). Skin symptoms caused by Asian dust have been reported in the past, and it has been said that physical irritation of exposed areas is the cause. The effect of the skin of the covering was also significant, and the allergy by the high internal exposure was suspected. The threshold value of the extinction coefficient of LIDAR for these symptoms was 0.0035/km for both Asian dsut (non-spherical) and pollutants (spherical). We will continue to scrutinize and analyze regional and seasonal impacts.

一般研究 30 General Research 30	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	マメ科作物ササゲの長距離シグナル遺伝子の多型性に着目した乾燥耐性品種差の解析 A study of genetic polymorphism of long distance signaling for drought tolerance among cowpea cultivars	
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. Recently, molecular genetic studies in Arabidopsis have revealed that the ABA responses are mediated by various long-distance signals including CLE peptids and ABA transporters. However, it remains unknown whether the transport mechanisms of ABA are involved in significant drought tolerance of cowpea.An artificial peptide of VuCLE25 peptide with hydoroxyl modification on proline residues was synthesized. Previously, we observed that drought stress induced up-regulation of VuCLE25, VuABCG25 and VuNCED-01g. Here we characterized expression profiles of *VuNCED* genes in response to CLE peptide and drought and effects of CLE peptide on root elongation of cowpea seedlings. Semi-quantitative RT-PCR analysis indicated that CLE peptide up-regulated expression of *VuNCED-02g* but not *VuNCED-01g*. In contrast, drought significantly up-regulated expression of *VuNCED-01g* but not *VuNCED-02g*. Treatment of VuCLE 25 peptide significantly suppressed elongation of root elongation of cowpea seedling. Those data indicated that functions of CLE25 peptide on ABA synthesis and root apical meristem regulation are highly conserved between cowpea and Arabidopsis and that VuCLE25 and drought differently regulated *VuNCED* genes.	

一般研究 31 General Research 31	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	モンゴル国ゴビ砂漠における移動式黄砂発生観測 Observation of Kosa emission using mobile observation system in Gobi Desert, Mongolia	
共同研究要旨 Summary of Joint Research	Land surface conditions in the East Asia are highly variable seasonally, and the impact of changes in land surface conditions on KOSA generation is complex. Since 2012, the Arid Land Research Center of Tottori University has been monitoring sand and dust in Tsogt-Ovoo village in the desert steppe area of the Gobi Desert in Mongolia including the observations of land surface conditions such as soil, gravel, and vegetation (Buyantogtokh et al., 2021: Wu et al., 2021). It is important to clarify the relationship among the saltation sand, dust and the land surface conditions. As in the previous year, we were unable to conduct a field survey in this year due to the new coronavirus, so we summarized the observation results obtained and also conducted numerical simulations (Kong et al., 2021). It is found that the threshold wind speed Ut decreased from 18.5 m/s to 12.3 m/s from February to early May and increased from 7.2 m/s to 19.5 m/s from late May to July (Figure 1). Thus, it is clear that strength of threshold wind speeds is divided into two periods. The saltation events were more active in 2012 (circles) and 2015 (crosses), which could be due to changes in soil crusts. Although these results are not the result of mobile observations, the long-term comparison of data at a single site allowed us to capture changes in multiple ground surface conditions. Numerical simulation results indicate that the 10-day maximum and 10-day minimum soil temperatures are related to changes in threshold wind speeds in spring, and that not only living vegetation but standing dead vegetation have a strong influence in early summer, in addition to the soil temperature. Since field observations could not be conducted in 2020 and 2021, based on the findings of this study, we will plan to elucidate the KOSA emission using the observation data we have obtained.	

一般研究 32 General Research 32	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	ムギ類における乾燥ストレスが脂質代謝に及ぼす影響の解明 Effects of drought stress on lipid metabolism in wheat and barley	
共同研究要旨 Summary of Joint Research	Plants are exposed to various stresses including pathogen infection and drought. Lipid metabolism plays a pivotal role in the response to these stresses. For example, oxylipin molecules are synthesized from fatty acids. In addition, the barley leaves have been shown to accumulate lyso-lipids in response to pathogen attack. These findings suggest that plants degrade diacylglycerolipids into fatty acids and lyso-glycerolipids, and synthesize oxylipins under stress conditions. We focused on the accumulation of lyso-lipids in the leaves of drought-stressed rice plants and pathogen-infected barley plants. Drought stress was applied by stopping water supply to rice plants 2 weeks after sowing. Lyso-galactolipids and lyso-phospholipids were analyzed 6 and 9 days after the start of treatment. In lyso-galactolipids, monogalactosyl monoacylglycerol with an acyl group at 1-position was accumulated. In contrast, lyso-phosphatidylcholine and lyso-phosphatidylethanolamine decreased significantly in the leaves after drought treatment. Conidia of barley spot fungus were inoculated on to barley leaves. Lyso-galactolipids accumulated 6 h after the inoculation, slightly prior to the that of lyso-phospholipids. The lyso-lipids with an acyl group at the 2-position of glycerol accumulated in larger amounts than those at the 1-position, suggesting the involvement of a lipase specific to the hydrolysis at the 1-position. The effect of pathogen infection on lysolipid accumulation was also analyzed in rice because abundant genomic information is available. The accumulation lyso-lipids was also observed in rice inoculated with rice brown leaf spot fungus. Thus, we selected 10 lipase genes of which expression increased in response to pathogen infection by using the gene expression database RiceXPro. Then, we identified the corresponding barley orthologs *Hvlip1* to *Hvlip10*, and analyzed their expression by real-time PCR. The expression level of *Hvlip1* was increased after pathogen inoculation, suggesting that Hvlip1 is involved in the production of lyso-lipids in response to pathogen infection.	

一般研究 33 General Research 33		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：節水型オオムギ・タルホコムギ系統の探索 Toward the breeding Triticeae varieties optimized for drylands: Searching for water-use-efficient barley and wild wheat lines		
共同研究要旨 Summary of Joint Research	To clarify the genetic basis of water-use-efficient (WUE) barley, we evaluated water-saving potential by measuring δ13C fractions in a near-isogenic line (NIL) containing two salt-tolerant QTL at the germination stage which selected in 2020-2021. Elemental Analyzer interfaced with a continuous-flow isotope ratio mass spectrometer (EA/IR-MS) analysis of dry leaves (6 * flag leaves/individual * 6 individuals * 2 environments) from the lines together with the donor and backcrossed parents were performed. While the backcrossed parent “Haruna Nijo” (Japanese malting variety) was significantly reduced δ13C values than the donor parent “Hayakiso 2” (Japanese landrace) between parents, the two NILs were not significantly different and no clear association with salt tolerance was found. On the other hand, 13C fractionation on bulk samples of the 53 chromosome segment substitution lines used for the NIL selection revealed some lines that showed reduced δ13C values than their parents. This was indicative of the existence of a wide range of WUE variations in this population. These are expected to provide useful material for uncovering the genetic basis of WUE in this species. For the purpose of the selection for WUE wild wheat lines, EA/IR-MS analysis was conducted on 20 lines of the *Aegilops tauschii*, which had evaluated for salt-tolerance at the germination stage, including a subpopulation that was distributed into high-salinity areas. The analysis showed no significant difference inδ13C values between the nine salt-tolerant TauL1 lines and the other subpopulations (TauL2; 10 lines, TauL3; 1 line), and no clear relationship with salt-tolerance at germination was found. Further studies are needed to investigate the intraspecific variation in more detail, such as by expanding the number of lines.		

一般研究 34 General Research 34		対応教員 Corresponding Staff	辻本　壽 Tsujimoto, Hisashi
研究代表者 Principal Researcher	坂　智広（横浜市立大学木原生物学研究所） Ban, Tomohiro (Kihara Institute for Biological Research, Yokohama City University)		
研究課題 Research Subject	コムギの頑健な根系形成能力の評価法と遺伝資源の選抜についての研究 Studies on development of a robust root system and screening useful germplasm of wheat.		
共同研究要旨 Summary of Joint Research	Effects on root system formation ability and growth with Duckweed fertilizer (DWF) containing a biostimulant (D-KODA) were observed using a rice cv. Koshihikari. By the Root Bag method, non-destructive growth of the root system could be observed along with the growth, and the feature amount could be detected by image analysis. The D-KODA/DWF treatment greatly changed the root/stem ratio during the seedling raising period. Under the flooded conditions assuming paddy field transplantation, the image analysis showed a difference in brightness to in the properties of the root surface. The heading was delayed by one day in the D-KODA/DWF treatment. The D-KODA treatment resulted in short culm and the number of spikes increased with highly resilience under the intense high temperature and drought stress during the ripening period. Low temperature germination at 4-6 °C after D-KODA/DWF treatment on wheat showed remarkable seed root elongation in Norin 61 but Afghan wheat landrace # 654. Rhizobacteria such as *Janthinobacterium*, *Duganella*, and *Massilia* which produce violacein were found in Norin 61, whose roots grew due to low-temperature germination through their symbiosis with roots. They showed slight inhibition of hyphal growth of *Fusarium fungus* of Fusarium head blight, and some showed high antifungal activity. We have found that biostimulant treatment of wheat modifies the rhizosphere flora and may tune the rhizosphere environment for seed root elongation and antifungal activity. The growth of seedlings was promoted by inoculation with a cocktail of isolated rhizosphere bacteria, and the volume of the root system was particularly increased with the effect of D-KODA/DWF on the moisture damage. Occasionally, *Erwinia persicina* causes red grains of barley was detected in the rhizosphere. We will clarify the effects of these non-pathogenic and consortium formation with other rhizosphere bacteria and the growth promoting effect of the wheat root system.		

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	徳本　家康（佐賀大学農学部） Tokumoto, Ieyasu (Faculty of Agriculture, Saga University)		
研究課題 Research Subject	気候変動緩和策のための局所密集根群を介した水・炭素循環機構の解明 Elucidating the mechanism of soil water・carbon cycles through high-density roots for climate change mitigation		
共同研究要旨 Summary of Joint Research	Objectives: For elucidating the mechanism of soil water・carbon cycles through high-density roots for climate change mitigation, we tried to develop CO2 gas monitoring system. Then, CO2 gas emission was investigated from an aggregated soil. Results: a. CO2 measurements without vegetation For the CO2 measurements, we used CO2 detector tubes (2LC, GASTEC), having a measuring range of CO2 from 100 to 4000 ppm. To avoid suck up soil water into the tube, a water-proof air-permeable filter was utilized. When soil moisture was lower than field water capacity for the aggregated soil, CO2 concentration in the macro-pore was approximately 1600 ppm. b. Development of CO2 gas measurement system CO2 measurements in a macro-pore with high-density roots were challenging. We developed a CO2 measurement system to observe temporal changes in CO2 concentration in a macro-pore under different moisture conditions. Using a micro-pump of gas and solenoid valves, sampling time and volume were controlled. CO2 concentration in the macro-pore under vegetation conditions was approximately 800 ppm. This suggests important contributions of the high-density roots to CO2 gas exchange due to high gas permeability. c. Field experiments We planned pre-field experiments for the shaft tillage method at a national agricultural institute in Mozambique during the dry season. Under COVID-19, however, it was too difficult to work on the experiments. In future work, the experiments will be carried on.		

一般研究 36 General Research 36		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	The purpose of this study is to understand long-term and wide-area vegetation dynamics by non-destructive methods using images of vegetation taken in the semi-arid grasslands of Mongolia. Although we planned to conduct a field survey in the summer of 2021, it was impossible to carry out overseas surveys due to the pandemic of COVID-19. Therefore the following analyses were performed using digital images automatically taken at BayanUnjuul (BU) and Baganuur (BN) sites during the period from 2016 to 2019. 1) To investigate impact of the solar elevation and orientation on GCC, images on days which were sunny and clear from sunrise to sunset were chosen. GCC showed step-like changes in the morning (around 11:00 local time (LT)) and in the afternoon (around 15:00 LT) and were relatively stable in the time between these changes (see Figure in the previous page). This result was common at both sites through the growing season. 2) We calculated weather filtering index (WFI) and used solar radiation and precipitation data for examining the effect of weather on GCC. When it rained, GCC showed extremely high values. Under dark cloudy conditions, WFI values were close to zero (< 0.01) and GCC was relatively high because the surface looked dark. In other seasons and other years, the similar diurnal variations in GCC and		

	WFI were observed at the BU and BN sites.

一般研究 37 General Research 37	対応教員 Corresponding Staff	辻本　壽 Tsujimoto, Hisashi
研究代表者 Principal Researcher	執行　正義（山口大学大学院創成科学研究科） Shigyo, Masayoshi (Graduate School of Sciences and Technology for Innovation, Yamaguchi University)	
研究課題 Research Subject	カロテノイド高蓄積ネギの乾燥ストレス耐性能の生理化学的評価 Physiological and chemical evaluation of drought tolerant capacity in carotenoid highly accumulated *allium* plants	
共同研究要旨 Summary of Joint Research	Abscisic acid (ABA) quantification using LCMS/MS Allium plant leaves (control and drought treated) harvested in 2020 were pulverized and freeze-dried. Methanol and stable isotope ABA were added to the dried powder. The mixture was incubated for 24 h at room temperature. The supernatant was collected and filtered. The filtered sample was used for LCMS/MS analysis (Fig.1). In comparison among control condition, ABA accumulation was highest 6A chromosome addition line (FF+6A). However, that of FF+6A under drought condition was not higher than any other lines. This suggests that ABA biosynthetic activity of FF+6A is low under drought condition. On the other hand, 1A chromosome addition line (FF+1A) had the highest ABA accumulation under drought condition although that is low under control condition. β-carotene quantification using HPLC The same dried powder as extraction of ABA was used for sample preparation. Acetone was added to the powder and the supernatant containing leaf extract was collected. After filtering the collected solution, the solution was injected to HPLC. β-carotene content was calculated using calibration curve drawn based on known concentration of β-carotene standard. Consequently, β-carotene content of FF+1A was highest under both conditions and there was no different pattern between control and drought (Fig.2). This suggests that β-carotene biosynthesis pathway is not affected by drought stress. In conclusion, the 2 possibilities were proposed from these results. The highest ABA accumulation of FF+1A indicate that ABA biosynthesis fully activate under drought condition by some genetic effects on chromosome 1A. The highest ABA accumulation of FF+6A under control condition indicate that ABA biosynthesis is constitutively high by some genetic effects on chromosome 6A.	

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	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耐塩性機構の解明 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, 200, 300 mM) for different time (0, 3, 6, 12, 24, 48 hours). After salt treatment, the cladodes and the roots were cut and were frozen in liquid nitrogen and stored in -80 degrees before use. After extraction of total RNA from these organs, we performed RTPCR and qRT-PCR with real time PCR using the primers specific for *DREB, SOS1, AKT1, AKT2* and *PFK6* genes based on the database sequence of *A. officinalis* and *A. kiusianus*. These genes were selected from the candidate genes associated with salt stress according to the previous publication. The results showed that *DREB* and *SOS1* genes did not show any changes in gene expression due to salt treatment. On the other hand, the expression levels of *AKT1* and *AKT2* genes were decreased by salt treatment. The expression of *PFK*6 gene was induced by salt treatment. The expression of the *PFK6* gene was more induced in roots than in cladodes. At 48 hours after treatment with 300mM NaCl, *PKF6* gene expression was induced approximately 7-fold and 13-fold in *A. officinalis* and *A. kiusianus*, respectively (Fig. 1, 2). These results indicate that the treatment method used in this study can induce the expression of the genes related to salt stress in these two species.	

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	衣笠　利彦（鳥取大学農学部） Kinugasa, Toshihiko (Faculty of Agriculture, Tottori University)
研究課題 Research Subject	温暖化がモンゴル寒冷乾燥草原における植物の晩霜耐性に与える影響 Effect of global warming on late frost tolerance of plants in the cold Mongolian steppe
共同研究要旨 Summary of Joint Research	It is concerned that global warming will advance the timing of plant germination and increase the risk of exposure of young plants to temporary low temperature (frost damage). Grassland vegetation in Mongolia is important for livestock production. Therefore, we examined changes in frost tolerance of grassland species in response to global warming to predict future changes in the risk of frost damage. In Experiment 1, we examined the changes in frost tolerance of two major grass species (*Agropyron cristattum* and *Stipa krylovii*) with growth after germination. Plants were exposed to low-temperature stress with -10°C for 3 hours at either 30, 40, or 50 days after planting. Plants were harvested immediately before and 15 days after the low temperature treatment, and above-ground dry mass was measured. *A. cristatum* showed a decrease in above-ground dry mass only in the low-temperature treatment at 30 days after planting. On the other hand, *S. krylovii* showed decrease in above-ground dry mass in all low-temperature treatments. These results suggest that warming may advance germination timing and increase frost tolerance through growth acceleration, though the effect varies among species. In Experiment 2, we determined interspecific differences in the warming effect on frost tolerance of grassland species. Six grassland species were grown in growth chambers for 30 days under normal and warming conditions (normal conditions + 5°C), followed by a 1-hour low temperature treatment. Low temperature treatments were performed at -3, -6, -9, -12, and -15°C. The EC of leaf soaking solution was measured, and the increase in EC due to low temperature treatment was considered as the frost damage. The temperature at which the degree of cell injury reached 50% (LT50) was estimated and used as an indicator of low temperature tolerance. The results showed that LT50 varied from -5°C to -17°C depending on the species and tended to increase with warming in most species. These results suggest that warming increases the risk of frost damage in Mongolian grasslands. As the warming sensitivity of frost tolerance varies among species, warming may affect species composition of grassland.

一般研究 40 General Research 40	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	黄砂バイオエアロゾルの気中耐性と生体影響を評価する機能メタゲノミクス Metagenomics analyses targeting airborne microorganisms transported by KOSA	
共同研究要旨 Summary of Joint Research	**Objectives:** Microbial dispersals by Asian dust events potentially influence ecosystem dynamics, human health and climate changes, in the westerly-wind over East Asia. However, the functional characteristics of airborne microorganisms were predicted depending on the taxonomic microbial compositions. Here, after the whole genomic DNA in bioaerosol samples were determined, the functional genes were analyzed using bioinformatics analyses (MAPLE :Metabolic and Physiological Potential Evaluator). **Results:** We collected aerosols at the Gobi Desert and the downwind areas, for analyzing the airborne microbial characteristics that are distributed vertically over desert area. MAPLE analyses using whole genomic DNA revealed that the functional genes were predominantly originated from the several bacteria species. The genes relating to osmotic regulation and sugar-organics synthesis were frequently detected form the high-altitude samples, suggesting the airborne bacteria resistant to atmospheric stressors by desiccation and biofilm formation. Antibiotic-resistance genes were also obtained from the genomic DNA databases. Presumably, airborne bacteria, which possesses atmospheric-stressors resistance as genomic levels, are transported to high altitudes of desert, and relate to the dispersal risks of antibiotics resistance around down-wind areas. The aflatoxin-producing fungi was isolated from the bioaerosol samples, suggesting the toxic producing genes should be focused on future.	

一般研究 41 General Research 41	対応教員 Corresponding Staff	藤巻　晴行 Fujimaki, Haruyuki

研究代表者 Principal Researcher	依田　清胤（石巻専修大学理工学部） Yoda, Kiyotsugu (Faculty of Science and Engineering, Ishinomaki Senshu University)
研究課題 Research Subject	落葉性広葉樹における樹液流動特性と樹幹内熱伝播特性の季節動態の比較と評価 Comparison and evaluation of the seasonal dynamics of sap flow and thermal diffusion in deciduous-broad leaved trees.
共同研究要旨 Summary of Joint Research	In the present research, we focused on the relation between drought- and freeze-tolerant properties of tree. We clarified so far that various patterns of heat conduction and convection occur in tree trunks, associated with sap flow in some cases or not in others. Heat dissipation method (HD) has been applied for the measurements because of its low cost and driving energy, convenient handling and long-term measurement potential. On the other hand, uncertainties are also reported for the method, which probably caused by calibration procedures with zero-flow condition, daily or local variability of sap flow, site- or species-dependency, and so on. To verify the accuracy and precision for the measurements of heat transport linking with sap flow in tree trunk, signals of heater and reference probes of HD were separately recorded and their daily and seasonal patterns were comparatively analyzed with meteorological parameters (ambient air temperature, humidity, wind speed, solar radiation, Variation of signals detected from the two probes were matched well each other and almost parallel to the seasonal change of ambient temperature. Daily fluctuation patterns of reference probe signals were comparable to those of ambient air temperature during leaf-expanding period, whereas the daily patterns of heater and reference probes were resembled each other during defoliation period. These different characteristics of temperature response in heater and reference probes induced 1) the seasonal transition of baseline in the temperature differential (dT, heater - reference) especially in early spring and late autumn, and 2) temporal difference of daily amplitude occurred between the two probes, which induced signal fluctuations as artifact.

一般研究 42 General Research 42	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	乾燥地油料果樹の改良と有効活用に関する研究 Research for improvement and effective usage of oil fruit trees in the arid land	
共同研究要旨 Summary of Joint Research	Since August 2017, the cultivation of jojoba has been performed on a 4.2 ha farm in Beheira, Egypt. Approximately 5,000 jojoba plants (about 4000 female cuttings and 1000 seedlings for pollen suplies) are cultivated. In this study last year, 173 excellent plants with good growth and high fruit density, as well as 36 standard plants, were selected from the cuttings-derived female strains, the seeds of each plant were collected from July to October, the harvest season of jojoba, and individual yields were measured and compared. As a result, more than 20 individuals had seed yields 1.5 times or higher than the average yield of the standard plants, and there was almost no correlation between tree height and seed yield. This year, the tree height and seed yield of the selected plants were measured again and compared with the results of last year. The average tree height was about 1.2 times that of last year, and the average seed yield was almost the same as last year. The seed yield variation among individuals was larger than last year, and more than 50 individuals had seed yields 1.5 times or higher than the average yield of standard plants. Unlike last year, there was a correlation between tree height and seed yield. Due to unseasonable weather in Egypt in 2021, it was reported that yields of olives and other crops decreased significantly. In Jojoba, there was no significant decrease in yield unlike olives, but environmental conditions might be involved in the difference from last year's results. We will coninue the investigation in the next financial year. To proliferate and conserve representative selected strains, we started to produce cuttings from 36 plants. To study clonal propagation of excellent jojoba plants by tissue culture, we acclimatized sterile jojoba plants grown on an agar medium to produce seedlings.	

一般研究 43 General Research 43	対応教員 Corresponding Staff	坪　充 Tsubo, Mitsuru
研究代表者 Principal Researcher	西原　英治（鳥取大学農学部） Nishihara, Eiji (Faculty of Agriculture, Tottori University)	

研究課題 Research Subject	ゴマの連作障害の主となる要因の解明 Elucidation of main factors in sesame continuous cropping failure
共同研究要旨 Summary of Joint Research	We elucidated the main causes of sesame continuous cropping failure and investigated the below three factors: 1) Imbalance of soil mineral nutrients 2) Allelopathy 3) Soil disease The following results of the study contributed new findings necessary for understanding the causes of continuous cropping disorder of sesame seeds. (1) The imbalance of exchangeable bases in soil is a part of the yield limiting factor, and the base saturation (%) was set to Ca2 +: Mg2 +: K + = 75: 25: 10 (%). It was clarified that adjusting the balance improved the grain yield by 13 to 52% and reduced the continuous cropping failure. (2) Hydroponics tests revealed that sesame root exudates have sufficient allelopathy to cause the growth inhibition. (3) As a result of BLAST search, *M. phaseolina* (stem rot) was identified as one of the major diseases in the continuous cropping field, which was the first report of soil disease of sesame in Japan. (4) It was clarified that the root exudate of sesame had a self-poisoning substance that suppresses the growth of sesame but had antibacterial activity against the growth of the identified *M. phaseolina* hyphae. In conclusion, the allelochemicals from sesame affected the growth of sesame itself. On the other hand, each fractionated crude extraction exuded from root could not completely suppress the hyphal growth of the soil disease identified in this study. The cause of the continuous cropping failure that reduces the yield of sesame was mainly considered to be more likely to be a soil disease than the allelopathic substance of sesame.

一般研究 44 General Research 44	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	GPS 受信機を利用した広域土壌水分計測の可能性検討 Possibility study of large-scale estimation of soil moisture using GPS receivers	
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. To compare the data from the GNSS receivers with measured SMC, Meter 5TE moisture sensors were installed at a depth of 2.5cm. The results from FSC showed that the estimated SMC from GNSS receivers showed relatively high correlation with SMC measured by 5TE sensors when we select appropriate satellites and analytical conditions, suggesting that combination of low-priced micro computers and GNSS receivers can be a tool to estimate large scale surface soil moisture.	

一般研究 45 General Research 45	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	根寄生雑草の発芽刺激物質の同定と生合成経路の解明 Identification of seed germination stimulants for root parasitic weeds and elucidation of their biosynthetic pathways
共同研究要旨 Summary of Joint Research	Methyl carlactonoate (MeCLA), found in Arabidopsis (*Arabidopsis thaliana*) as a non-canonical strigolactone (SL), may be a biosynthetic intermediate of various noncanonical SLs and biologically active as a plant hormone. MeCLA is formed from carlactonoic acid (CLA), but the methyltransferases (MTs) converting CLA to MeCLA remain unclear. Previous studies have demonstrated that the carboxy methylation of acidic plant hormones is catalyzed by the same protein family, the SABATH family. In the present study, we focused on *At4g36470* gene, an *Arabidopsis SABATH MT* gene co-expressed with the *MAX1* gene responsible for CLA formation for biochemical characterization. The recombinant At4g36470 protein expressed in *Escherichia* coli exhibited exclusive activity against naturally occurring (11 R)-CLA among the substrates, including CLA enantiomers and a variety of acidic plant hormones. The apparent Km value for (11 R)-CLA was 1.46 μM, which was relatively smaller than that of the other Arabidopsis SABATH MTs responsible for the carboxy methylation of acidic plant hormones. The strict substrate specificity and high affinity of At4g36470 suggested it is an (11 *R*)-CLA MT. Phylogenetic analysis demonstrated that At4g36470 and its orthologs in non-canonical SL-producing plants cluster together in an exclusive clade, suggesting that the SABATH MTs of this clade may be involved in the carboxy methylation of CLA and the biosynthesis of noncanonical SLs.

一般研究 46 General Research 46		対応教員 Corresponding Staff	辻本　壽 Tsujimoto, Hisashi
研究代表者 Principal Researcher	児玉　基一朗（鳥取大学農学部） Kodama, Motoichiro (Faculty of Agriculture, Tottori University)		
研究課題 Research Subject	日本各地に自生するイネ科植物からの *Epichloë* 属エンドファイトの分離と耐乾性・耐塩性付与への活用 Isolation of *Epichloë* endophytes from Poaceae plants in Japan and its application for developing drought/salt tolerant crops		
共同研究要旨 Summary of Joint Research	*Epichloë* sp. is a symbiotic endophyte of the grass subfamily Pooideae, which produces the livestock toxic compounds indole-diterpene and ergot alkaloid (E) as secondary metabolites, and the entomotoxic compounds loline alkaloid and peramine. For the agricultural use of this endophyte, it is essential to select and utilize strains that produce only entomotoxic compounds. Since this fungus is symbiotic with some plants of the genus *Elymus*, a closely related species of wheat, we collected *El. tsukushiensis* from Tottori and other prefectures and *El. dahuricus* from Hokkaido, and isolated *Epichloë* spp strains. After surface sterilization of the plants, they were placed on PDA medium, and the growing mycelia were cultured passively. Colony characteristics and spore morphology of the isolated strains were observed. Phylogenetic analysis based on the rDNA ITS region, β-tubulin gene, and TEF1-α gene sequences identified all isolates as *E. bromicola*. The multiplex PCR was used to test for the presence of each toxic compound biosynthesis gene, and in addition to strains carrying the ergot alkaloid/peramine genes, strains carrying the loline alkaloid/peramine or peramine genes were found. Furthermore, HPLC and LC-MS analyses of the biosynthesis of the compounds in the host plants symbiotic with the peramine gene-carrying strains indicated the possibility that peramine is actually accumulated in the host plants.		

(4) 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	谷口　武士 Taniguchi, Takeshi
研究代表者 Principal Researcher	龍見　史恵（北海道大学農学研究院） Tatsumi, Chikae (Research Faculty of Agriculture, Hokkaido University)		
研究課題 Research Subject	重金属汚染土壌において養分供給機能を介して植物定着を助ける鍵微生物の探索 Key microbiome to help plant growth through nutrient supply under heavy metal contaminated soils		

共同研究要旨 Summary of Joint Research	In this study, we aimed at revealing the microbial properties which is specifically found in the soils beneath healthy plants under heavy meatal pollution. It was difficult to go to the soil sampling in Zambia because of the COVID situation, but we successfully imported some frozen soil and plant samples from Zambia to Japan thanks to the collaborators working in Zambia. For this reason, we are currently working on the DNA extraction and chemical analysis for these samples. Alternatively, we conducted several experiments in the lab to see microbial changes in Pb-contaminated soils. One of the experiments was to know soil microbial changes over days after various level of Pb addition. Another experiment is to test the effect of manure addition and animal (mice) presence on soil microbes under Pb pollution. From these experiments, we found that high Pb concentration simplify the microbial network. Also, the Pb pollution reduced soil nitrifier abundance and net nitrification rate, but the manure addition and mice presence improved the nitrifier population and nitrification rate. In further analysis for Zambian soil we imported, we plan to focus on whether these microbial properties which was degraded by Pb pollution (i.e., network complexity and nitrifiers) is improved beneath healthy plants.

若手奨励研究 2 Incentive Research by Young Scientists 2		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	We experimentally examined the effect of salinity stress on the relationships between mangrove plants and arbuscular mycorrhizal fungi (AM fungi). Two Rhizophoraceae mangrove species, *Rhizophora* *stylosa* and *Bruguiera gymnorhiza*, were cultivated in pots filled with mangrove soils for three months in a glasshouse. Then, half of the seedlings were grown in pure water, while the others in 0.2 M NaCl solution. As a result, *R. stylosa* exhibited no mycorrhiza formation in their roots, regardless of the treatments. In contrast, all *B. gymnorhiza* roots in the pure water treatment were infected by AM fungi. However, the trophic relationships of *B. gymnorhiza* with AM fungi were weaken in the salinity treatment; AM fungal structures were found only in one *B. gymnorhiza* seedling in the salinity treatment. In addition, *B. gymnorhiza* leaves in the salinity treatment exhibited low C/N and C/P ratio, suggesting that the salinity stress inhibited their assimilation rates and induced the redundancy of nitrogen and phosphorus. As a next step, we extracted AM fungal spores from mangrove soils (see the photo in the previous page) and isolated them using a microscope. We are trying to increase these spores using sorghums (see the right photo) and plan to inoculate the spores into the mangrove plants.		

若手奨励研究 3 Incentive Research by Young Scientists 3		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	<u>Proceeding generation of RIL lines</u> Water-saving and -wasting candidate genotypes selected from field trial in Sudan were crossed each other. Two types of crossed hybrid (F1) were grown to obtain F2 population. The RIL population “set1” was only used for experiments in this fiscal year. The both sets keep being self-propagated to obtain F7 generation genotypes with speed-breeding method in Yamaguchi University. <u>Measurement of carbon isotope ratio</u> The matured flag leaves from 261 genotypes of set1 (F2) were harvested and their carbon isotope ratio was measured using IR-MS in ALRC. As a result, the values ranged from approximate -26 to -36 in this set. This result indicates that the RIL population contains genotypes with various water-saving		

	levels. Thus, the population are expected to become RIL experimental lines with diverse water-saving traits and genetic backgrounds Cultivation of RIL lines in the field to evaluate traits To evaluate carbon isotope ratio and yield-traits (spike number, spike weight, seed number and seed weight) of set1 RIL (F6) grown in Yamaguchi University, they were started to cultivate in the field of ALRC from the end of November, 2021. Harvesting and collecting samples for evaluation of yield-traits and carbon isotope ratio is going to be performed in June, 2022. The harvested seeds are going to be used for the other physiological and agronomical experiments later.

若手奨励研究 4 Incentive Research by Young Scientists 4		対応教員 Corresponding Staff	石井　孝佳 Ishii, Takayoshi
研究代表者 Principal Researcher	殿崎　薫（岩手大学農学部） Tonosaki, Kaoru (Faculty of Agriculture, Iwate University)		
研究課題 Research Subject	乾燥地適応型イネの開発を目指した生殖的隔離の打破 Overcoming of the species barrier for the development of dry condition adapted rice		
共同研究要旨 Summary of Joint Research	Abnormal endosperm development caused hybrid lethal as one of the post-zygotic barriers and often observed by an interspecific cross between cultivated and wild rice. We previously have shown that mis-expression of several genes may cause the abnormal development of endosperm in the hybrid endosperm. Besides, we also revealed epigenetic modification controls mis-expressed genes such as DNA methylation and histone modification. Therefore, we predicted to change the epigenetic information in hybrid endosperm overcome the endosperm barrier in the interspecific cross. We used emf2a mutant, which mediates the repressive histone marks (H3K27me3), for the interspecific cross with wild rice. An interspecific cross between cultivated rice, Oryza sativa, and wild rice, Oryza australiensis, forms shrink endosperm leading and decrease viability in hybrid seed lethality. In contrast, when the emf2a mutant rice used as a maternal parent crossed with Oryza australiensis, hybrid endosperm develops normally and restores viability. Hence, this results shown that we can partial ocvercome the post-zygotic barriers in interspecific crosses by reducing the H3K27me3 level in the hybrid endosperm.ly		

若手奨励研究 5 Incentive Research by Young Scientists 5		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			

若手奨励研究 6 Incentive Research by Young Scientists 6		対応教員 Corresponding Staff	藤巻　晴行 Fujimaki, Haruyuki
研究代表者 Principal Researcher	柳川　亜季（明星大学理工学部） Yanagawa, Aki (School of Science and Engineering, Meisei University)		
研究課題 Research Subject	植生指数から算出した生態系機能評価指標を用いた砂漠化の進行速度の推定 Estimation of Desertification Progress using with Index of Ecosystem Function		
共同研究要旨 Summary of Joint Research	Desertification has been estimated from various perspectives, such as meteorology and geography. Desertification indicates the changing of the vegetation and the ecosystem function. However, the evaluation of the decertified area in terms of ecosystem function is not fully understood. Therefore, we calculated the time series fluctuation of desertification using the ecosystem function index (resistance and resilience). Resistance is known as the ability of an ecosystem to remain unchanged after being exposed to extreme climate events. Resilience represents the ability of an ecosystem to recover from damage after extreme events. We used MODIS satellite-based Normalized Difference Vegetation Index (NDVI) and short-term Standardized Precipitation Evapotranspiration Index (SPEI) data. Resistance and resilience were cal-		

	culated from NDVI. We calculated SPEI from Precipitation (GPCC) and potential evapotranspiration (CRU-TS) by the R library of SPEI. We focused on the duration of 2001-2020. Time and space resolution were monthly and 5 minutes (about 10km2:2160x4320grids). We estimated desertification in drylands except for croplands by resistance and resilience during the drought, which was determined from the SPEI. The results show the fluctuation of resistance and resilience, which indicates the condition of desert areas. We could not find clear trends of resistance and resilience with the drought degree from SPEI in drylands. Therefore, we will analyze the desertification from resistance and resilience in each land cover. This result was accepted as an oral presentation at an international conference of EGU.

若手奨励研究 7 Incentive Research by Young Scientists 7		対応教員 Corresponding Staff	辻本　壽 Tsujimoto, Hisashi
研究代表者 Principal Researcher	佐久間　俊（鳥取大学農学部） Sakuma, Shun (Faculty of Agriculture, Tottori University)		
研究課題 Research Subject	乾燥地におけるコムギ脱粒性メカニズムの解明 Elucidation of wheat grain shattering mechanism in dryland		
共同研究要旨 Summary of Joint Research	In this study, we aim to elucidate the genetic factors of the grain shattering of bread wheat, which is a problem in drylands. The grain yield of wheat is greatly affected by the inflorescence (spike) morphology, and the yield is improved by increasing the number of grains per spike. However, some wheat varieties cultivated in drylands such as Sudan show grain shattering habits in which grains fall to the ground before harvesting. This results in a yield loss of about 30%, thus the development of non-shattering varieties is required. Therefore, the purpose of this study is to elucidate the mechanism of grain shattering and identify DNA markers for the efficient development of non-shattering varieties. The introduction of non-shattering varieties is expected to improve yield and stabilize, leading to sustainable wheat production in drylands. In the 2021-2022 season, the relationship between the degree of shattering and the curvature of the awns was examined under field conditions and the controlled growth chamber conditions (left in the figure). As a result, it was found that in all the populations, the lines with curved awns at the maturity stage have a high degree of shattering habit. When the spikes after heading were cultured with a controlled growth chamber that reproduced the climate of Sudan, a similar tendency was observed. From this, it was considered that non-shattering strains could be selected, and their responsible loci could be identified by investigating the presence or absence of awn curvature. Therefore, we investigated the awn phenotype of plants cultivated in the ALRC field conditions in the late maturity of the bread wheat core collection 190 lines developed by the NBRP wheat and conducted a genome-wide association study (GWAS) to estimate related loci. As a result of GWAS, significant correlation markers were identified in multiple chromosomal regions (right in the figure). Based on this information, we plan to proceed with QTL analysis in the segregating population and develop markers that can be used for DNA marker-assisted selection.		

⑸ 乾燥地×温暖化プロジェクト / Project ICC × DRYLANDs

温暖化プロジェクト 1 Project ICC × DRYLANDs 1		対応教員 Corresponding Staff	谷口　武士 Taniguchi, Takeshi
研究代表者 Principal Researcher	龍見　史恵（北海道大学農学研究院） Tatsumi, Chikae (Research Faculty of Agriculture, Hokkaido University)		
研究課題 Research Subject	重金属汚染土壌において養分供給機能を介して植物定着を助ける鍵微生物の探索 Key microbiome to help plant growth through nutrient supply under heavy metal contaminated soils		
共同研究要旨 Summary of Joint Research	Objective High temperatures occurring during flowering and early grain filling substantially decrease cereal yields. Given the accumulated evidence showing that crop canopy temperature (Tc) better explains observed yield reductions caused by heat stress than air temperature (Ta), this study evaluates the usefulness of Tc, relative to Ta, in designing high temperature indicators for agricultural monitoring and forecasting. Methods The hot and dry environment of Sudan provide an ideal testbed in examining the explanatory power		

	of using Tv instead of Ta for yield anomaly. Tc is derived from crop model and land surface model simulations. We used the regressions linking the high temperature indicators (calculated from either Tc or Ta) with irrigated wheat yield variations in three regions of Sudan over the last half century. Results We find that using phenological periods instead of months for the entire wheat season (November to February), as well as using Tc instead of Ta, clarify the adverse effects of high temperature on yield during the key periods. The Tc-based indicators calculated for the key phenological periods are characterized by their more robust multiregion applicability than the Ta-based indicators calculated for the months and season, although they do not necessarily outperform the region-specific indicators in terms of their explanatory power. The detected key period is the vegetative growth period for the relatively cooler region (Dongola) but the reproductive growth period for the relatively hotter regions (Wad Medani and New Halfa). These findings encourage agricultural monitoring and forecasting at national and scales incorporation of Tc-based indicators.

温暖化プロジェクト 2 Project ICC × DRYLANDs 2	対応教員 Corresponding Staff	衣笠　利彦 Kinugasa, Toshihiko
研究代表者 Principal Researcher	佐々木　雄大（横浜国立大学大学院環境情報研究院） Sasaki, Takehiro (Graduate School of Environment and Information Sciences, Yokohama National University)	
研究課題 Research Subject	モンゴル草原植生の気候変動への感受性を規定する要因：生態系の抵抗性と回復性に着目して Factors regulating the sensitivity of Mongolian grassland vegetation to climate changes: focusing on ecosystem resistance and resilience	
共同研究要旨 Summary of Joint Research	Future aridification in terrestrial ecosystems due to ongoing climate change will affect ecosystem structure and functioning. Ecosystems are full of thresholds in their responses to climate and land-use changes as well as in the way their components relate to each other. An ecological research priority is to develop a management scheme that can secure essential ecosystem functioning and services in highly stochastic environments. Recent efforts have identified the climatic thresholds in ecosystem functions and in their relationships to biodiversity in a range of ecosystems. In this study, we go beyond current knowledge, exploring climatic thresholds in ecosystem stability and stability-biodiversity relationships across Mongolian grasslands. Ecosystem stability over time is a fundamental property of any ecosystem for the stable provisions of ecosystem services despite variations in environmental conditions and disturbance. Based on the data from 813 sites covering whole Mongolia over 8 consecutive years (2012 to 2019), we detected potential climatic thresholds in the temporal stability of plant productivity, biodiversity, and stability components including species stability and synchrony. We further evaluated how relationships between biodiversity or stability components and temporal stability of productivity shift along extensive climatic gradients across Mongolia. We showed that temporal stability of productivity, stability components, and diversity change abruptly with aridity. Species richness and species stability generally enhance ecosystem stability despite variations in aridity. Species synchrony matters in ecosystem stability in more arid areas but not in less arid areas, and the switch in stabilizing mechanism occurs at aridity level of 0.8. Our study suggests that synchrony matters in more arid areas, indicating that the loss of temporal complementarity among species due to environmental change depauperates ecosystem stability in drylands.	

温暖化プロジェクト 3 Project ICC × DRYLANDs 3	対応教員 Corresponding Staff	黒崎　泰典 Kurosaki, Yasunori
研究代表者 Principal Researcher	立入　郁（海洋研究開発機構地球環境部門） Tachiiri, Kaoru (Research Institute for Global Change, Japan Agency for Marine-Earth Science and Technology)	
研究課題 Research Subject	アジア・アフリカ乾燥地の将来乾燥度変化 Change in future aridity in Asian and African drylands	
共同研究要旨 Summary of Joint Research	(Aridity Index) In order to clarify the factors that cause the differences in trends between changes in the Aridity Index and future changes in vegetation in Earth System Models (ESMs), an experiment was conducted using an ESM with fixed CO2 concentration perceived by the vegetation. The results showed that Gross Primary Production (GPP) and Leaf Area Index (LAI) remained unchanged to slightly increased in Mongolia without CO2 fertilization effect, but decreased in the Sahel. In both cases, the CO2 fertilization effect was dominant, and GPP and LAI increased with that effect. (Terrestrial Ecosystems) By comparing satellite observation-based data sets (“satellite data”) and	

	terrestrial ecosystem model results (on 1982-2014), uncertainties among “satellite data” and the reproducibility of satellite observations by terrestrial ecosystem models were evaluated. The results showed that GPP has declined since 2000 in all data sets, and that interannual variation in GPP correlated well with interannual variation in annual precipitation in the “satellite data,” but in some models, interannual variation in GPP was highly correlated with temperature rather than precipitation. (Regional Climate Model (RCM)) Due to the need for input data for the terrestrial ecosystem model (DAYCENT), downscaling was conducted for periods not previously covered (2006-2015, 2036-2045, 2066-2079) (model: HadGEM2 and scenarios: RCP4.5 and 8.5). The RCM outputs for temperature (daily maximum, minimum, and mean), precipitation, and wind speed at 60 meteorological stations were bias-corrected for these periods. In addition, we compared and verified two types of GSMaP satellite precipitation products with and without rain gauge correction for the entire Mongolian region, and summarized the characteristics and cautions of each precipitation product by verifying GPM observations and GSMaP products based on a case of heavy precipitation in the summer season in the area surrounding Ulaanbaatar. Further, a quasi-warming experiment was conducted using an RCM for a case of small/large precipitation events. As a result, it was confirmed that under global warming the range of weak precipitation areas narrows and that areas of intense rainfall (mainly in mountainous regions) locally tend to increase.

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, 2022

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)

(2) 国際共同研究 International Joint Research

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：2019 年 7 月－ 2022 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)・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：限界地プロジェクト
課題：モロッコの実験圃場において、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。

(2) International Joint Research

Simulation-Based Schemes to Determine Economical Irrigation Depths Considering Volumetric Water Price and Weather Forecasts

Period: Jul. 2019 - May 2022
Leader: H. Fujimaki (ALRC, Tottori University)
Organization: ICARDA, Tottori University
Funding: Development of crop husbandry technology in marginal rainfed environment using dryland plant resources
Subject: Exacerbating water and food insecurity urges more efficient use of water in irrigation through volumetric water pricing. In this context, a field experiment was carried out to assess the feasibility of a simulation scheme, called three-point used to determine irrigation depths considering volumetric water pricing and weather forecasts in comparison to both rain-fed scheme and a simulation-based refilling scheme, which was used to return the volumetric water content to field capacity.

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－ 2022 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（安萍）
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、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。

Elevating effects of brassinolide application on wheat growth, nutritional content, antioxidant activity and yield under saline conditions

Period: Dec. 2019 - Mar. 2022
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. 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.

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－ 2022 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

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

Period: Apr. 2019 - Mar. 2022
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 morphologi-

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。

cal, 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.

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－ 2022 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。

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

Period: Apr. 2019 - Mar. 2022
Leader: M. Irshad (University of Peshawar)
Organization: COSMAT University Islamabad, Pakistan (M. Irshad), ALRC Tottori University (P. An, Y. Shao)
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.

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（鳥取大学乾燥地研究センター）
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。

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

Period: Apr. 2017- Mar. 2023
Leader: A. Tsunekawa (ALRC, 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 proj-

ect 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.

砂漠化地域における地球温暖化への対応に関する研究
期間：2017 年 4 月－ 2022 年 3 月
代表者：山中典和（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（山中典和、黒崎泰典、衣笠利彦、坪充）・モンゴル気象水文環境情報研究所（P. Gomboluudev, B. Gantsetseg）・スーダン気象庁（Ahmed M. Abdelkarim）・スーダン農業研究機構（Imad-E. A. Ali Babiker, Amani A. M. Idris, Izzat S. A. Tahir）
研究費：鳥取大学
課題：温暖化の進行とともに極端な気象現象が増加すると指摘されている。乾燥地においても、地球温暖化が原因と考えられる熱波・干ばつといった気象災害が頻発し、食糧不足など生活を直撃する影響が生じている。本プロジェクトでは、(1) 熱波・干ばつ等の将来気候の解析を行い、(2) これらの砂漠化・農業への影響を明らかにし、(3) これらのリスクに対する適応･砂漠化対処策の開発を行っている。モンゴルにおいては気候変動の草原生態系への影響、スーダンにおいてはコムギ生産への影響をテーマとした研究を進めている。

Impacts of climate change (ICC) on Drylands: Assessment and Adaptation
Period: Apr. 2017 - Mar. 2022
Leader: N. Yamanaka (ALRC, Tottori University)
Organization: Tottori University (N. Yamanaka, Y. Kurosaki, T. Kinugasa, M. Tsubo), Information and Research Institute of Meteorology, Hydrology and Environment, Mongolia (P. Gomboluudev, B. Gantsetseg), Sudan Meteorological Authority (Ahmed M. Abdelkarim), Agricultural Research Corporation, Sudan (Imad-E. A. Ali Babiker, Amani A. M. Idris, Izzat S. A. Tahir)
Funding: Tottori University
Subject: It is pointed out that global warming increases the frequency of extreme weather events. Disasters such as heat wave, drought etc. frequently occur in drylands as well, and they have impacts like food scarcity. In this project, (1) we have conducted analyses of future climate from the viewpoint of such disasters; (2) we have assessed their impacts on desertification and agriculture; and (3) we have developed adaptation technologies to mitigate their associated risks. We have proceeded researches for their impacts on grassland ecosystem in Mongolia and their impacts on wheat production in Sudan.

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－ 2022 年 3 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。

Breeding analysis for pleiotropic effects on canopy temperature and related traits in bread wheat
Period: Apr. 2018 - Mar. 2022
Leader: Y. Yamasaki (ALRC, Tottori University)
Organization: Tottori University (Y. Yamasaki), Agricultural Research Corporation, Sudan (Izzat S. A. Tahir)
Funding: Kakenhi (2018-2021), SATREPS (2021-2022)
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.

フィリピン・糖尿病予防対策強化プロジェクト：自己効力感理論に基づく糖尿病自己管理・ピアサポートプログラムの効果
期間：2017 年 1 月－ 2022 年 3 月
代表者：小林伸行（鳥取大学乾燥地研究センター）
組織:鳥取大学（小林伸行､景山誠二､谷村千華､深田美香､花木啓一、徳嶋靖子、大谷眞二、大倉毅、井上和興、青戸春香（元））･大阪大学大学院医学研究科（長田アビル）･パテロス町役場（レイナルド・フローレス）
研究費：鳥取大学国際乾燥地研究教育機構、JICA 草の根技術協力「フィリピン・マニラ首都圏低所得者層地域における生活の質改善を目指した糖尿病予防プロジェクト」
課題：糖尿病患者の病態を改善し、生活の質を向上させるための患者教育手法の 1 つである「ピアサポート」の

Project for enhancing the preventive measures for diabetes in Philippines: Effects of Diabetes Self-management and Peer Support Program based on Social Cognitive Theory
Period: Jan. 2017 - Mar. 2022
Leader: N. Kobayashi (ALRC, Tottori University)
Organization: Tottori University (N. Kobayashi, S. Kageyama, C. Tanimura, M. Fukada, K. Hanaki, Y. Tokushima, S. Otani, T. Okura, K. Inoue, H. Aoto), Osaka University (A. Nagata), Municipality of Pateros (R. Flores)
Funding: International Platform for Dryland Research and Education of Tottori University; Grassroots Project on Health Promotion and QOL Improvement for Diabetics in Metro Manila of Japan International Cooperation Agency (JICA).
Subject: Peer support is a measure to improve the diabetes-pa-

低所得者層地域での妥当性を明らかにするため、疾病の自己管理に関する知識や経験を患者リーダーに指導した。その後、同リーダーおよび同リーダーが指導する他患者の疾病関連指標を半年ごとに調査した(2017～2019年)。2021年には、指導活動を通じた同リーダーの意識の変化(質的データ)をもとに、活動の継続性を強化するために必要な要因を分析した。

tients' health conditions and their QOL. To determine the relevance of peer support in a low-income community, we initially had a training for the peer leaders on diabetes self-management. Then, we measured diabetes-related indicators of the peer leaders and the other patients educated by the peer leaders every 6 months for 2 years, from 2017 to 2019. In 2021, based on the recorded changes of peer-leaders' cognition and emotions, we qualitatively explored the factors to encourage the leaders to continue their education program for other patients.

レーザー検知器を用いた泌乳フォガラ種乳牛のメタン発生量の測定および飼養方法の評価

期間：2019年6月－2021年5月
代表者：恒川篤史（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（恒川篤史、小林伸行)・アムハラ州農業研究所アンダサ畜産試験場（シグダフ・メクリアウ、ベヤドゥグリン・フネガウ、ウォンディメナ・メコネン)・バハルダール大学（フィレウ・テゲグネ、イェシャンベル・メクリアウ)・中国蘭州大学（候扶江)・島根大学（一戸俊義）
研究費：鳥取大学限界地プロジェクト、SATREPS「砂漠化対処に向けた次世代型『持続可能な土地管理』フレームワークの開発」(JST/JICA)、中国国家重点科学技術支援プログラム、中国国家自然科学基金、中国大学長江先端的研究プログラム
課題：エチオピア乾燥地での在来フォガラ種乳牛の放牧および舎飼い条件でのメタン排出量を、レーザー式メタン検知器を用いて評価した。同排出量を抑制しながらも乳量を上げられたことで、乾燥地における慣行放牧に代わる舎飼い飼養の可能性を提示した。成果を2021年8月に公表するとともに、同評価法を説明する動画を作成して現地関係者に配布、同評価法に関する今後の研究の発展の一助とした。

Evaluation on feeding confined Fogara dairy cows with the quantification of methane emissions using laser methane detector

Period: Jun. 2019 - Aug. 2021
Leader: A. Tsunekawa (ALRC, Tottori University)
Organization: Tottori University (A. Tsunekawa, N. Kobayashi), Andassa Livestock Research Center, Amhara Regional Agricultural Research Institute (S. Mekuriaw, B. Hunegnaw, W. Mekonnen), Bahir Dar University (F. Tegegne, Y. Mekuriaw), Lanzhou University (F. Hou), Shimane University (T. Ichinohe)
Funding: Marginal Region Agriculture Project of Tottori University; SATREPS—the Project for Development of Next-generation Sustainable Land Management (SLM) Framework to Combat Desertification (No. JPMJSA1601) of Japan Science and Technology Agency (JST) and Japan International Cooperation Agency (JICA); National Key Project of Scientific and Technical Supporting Programs of China (2014CB138706); National Natural Science Foundation of China (No. 31172249); Program for Changjiang Scholars and Innovative Research Team in the University of China (IRT13019).
Subject: The methane emission from Ethiopian local dairy cows grazed on natural grassland or kept under confined feeding was evaluated by laser methane detectors (LMD) in dryland of Ethiopia. Increases in the milk yield without increases in CH_4 emissions suggested confined feeding as an alternative to conventional grazing in drylands. These findings were published in August 2021. Moreover, a video material about how to measure CH_4 emissions with LMD was produced and distributed to the co-researchers in Ethiopia so that it will be further studied for application in the field.

ササゲの半数体作成法の確立

期間：2021年4月－2022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

Establishment of haploid inducer in cowpea

Period: Apr. 2021 - Mar. 2022
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

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。

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.

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 6 月－ 2024 年 6 月
代表者：辻本壽（鳥取大学乾燥地研究センター）
組織：鳥取大学（辻本壽、ヤシル・ゴラフィ、山崎裕司、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: Jun. 2018 - Jun. 2024
Leader: H. Tsujimoto (Tottori University)
Organization: Tottori University (H. Tsujimoto, Y. S. A. Gorafi, Y. Yamasaki, 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 purpose of this research is to rapidly develop dry and heat tolerant and nutritious and high-quality wheat varieties by molecular breeding technology and to effectively spread them by information communication technologies. The sub-Saharan region, including Sudan, has the most undernourished population and the demand for wheat is particularly high. However, the dry and hot environment is an obstacle to the production. In this project we are constructing breeding base to develop practical varieties by using the dry and heat tolerant wheat lines that was developed in the previous studies.

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（福井県立大学）
組織：福井県立大学（松岡由浩）、鳥取大学（辻本壽、石井孝佳、佐久間俊）、神戸大学（宅見薫雄）、国際トウモロコシ・コムギ改良センター（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。

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 (Fukui Prefectural University)
Organization: Fukui Prefectural University (Y. Matsuoka), Tottori University (H. Tsujimoto, T. Ishii, S. Sakuma, Kobe University (S. Takumi), International Maize and Wheat Improvement Center (M. Kishii)
Funding: Fund for the Promotion of Joint International Research (Fostering Joint International Research (B))
Subject: This study will produce a large number of “octoproid synthetic wheat (AABBDDDD)” by crossing and embryo culture of a core collection of wheat ancestral wild species, *Aegilops tauschii* (DD) with hexaploid bread wheat, *Triticum aestivum* (AABBDD genome). Then, new technology will be developed and established to introduce and use the diverse alleles of *Ae. tauschii* into *T. aestivum*. In the past 100 years, Japan has led the world in wheat research, including the discovery of wheat chromosome number and the elucidation of the evolution of polyploidy, and has the highest level of research resources (human resources, technology, and genetic resources). This research will take advantage of the opportunity afforded by the completion of genome sequencing to mobilize research resources and promote collaboration with the International Maize and Wheat Improvement Center (CIMMYT, Mexico) to solve the problem of food production under climate change.

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（鳥取大学乾燥地研究センター）
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。

Development and identification of bread wheat resilient germplasm for Qatar
Period: Jan. 2021 - Dec. 2023
Leader: H. Tsujimoto (ALRC, Tottori University)
Organization: Tottori University (H. Tsujimoto, Yasir S. A. Gorafi), Qatar University (Talaat A. Ahmed, Mohammed Al-Safran, Walid Kriaa)
Funding: QU Marubeni Grants
Subject: Wheat is one of the main food security crops in many countries around the world including Qatar. Qatar depends mainly on imports to meet the domestic demand for wheat. Wheat production in Qatar is very low and fluctuating from season to season with the fluctuation of the cultivated and harvested area. This low productivity is mainly due to the lack of well-adapted bread wheat varieties and suitable production technologies. It is reported that there is a dire need to develop genotypes that are either tolerant to terminal heat stress or that mature early without yield losses to escape the stress. Therefore, to pave the way for sustainable wheat production in Qatar well-adapted, high-yielding varieties and production technologies should be developed taking into account the limited water resources and poor soil quality. In this research, a unique bread wheat germplasm developed and tested under stress conditions will be used to identify suitable bread wheat germplasm for wheat production and improvement in Qatar.

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（グゥルベルト・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う。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う。

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 is conducted to understand crop responses to the seasonality of current and future climates. Specifically, the Japanese team develops and validates a crop model, while the African team conducts climate data analysis, climate forecasts, yield surveys and field trials, and farmer’s vulnerability assessment and climate change impact assessment.

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－ 2023 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：限界地プロジェクト
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 2023
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－ 2023 年 3 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（Z. Feras）・鳥取大学乾燥地研究センター（藤巻晴行）
研究費：鳥取大学国際乾燥地研究教育機構
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 – Mar. 2023
Leader: H. Fujimaki (ALRC, Tottori University)
Organization: National Agricultural Research Center of Palestine (Z. Feras), Tottori University (H. Fujimaki)
Funding: IPDRE (Irrigation and Water Resources Management Group), Tottori University
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.

（3）外国人研究者・受託研究員・研究生の受入れ

外国人研究者

Xin Long
（令和 3 年 10 月 1 日～令和 4 年 9 月 30 日）
アデレード大学心理学部・大学院生
私費

研究生

Taye Minichil Meshesha
（令和 2 年 10 月 1 日～令和 3 年 9 月 30 日）エチオピア
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

(3) Visiting Researchers, Trainees and Research Students

Visiting Researchers

Xin Long
(Oct. 1, 2021 – Sep. 30, 2022)
Graduate student, School of Psychology, the University of Adelaide
Private funds

Research Students

Taye Minichil Meshesha
(Oct. 1, 2020 - Sep. 30, 2021) Ethiopia
Alebachew Tareke Kehali
(Oct. 1, 2021 - Sep. 30, 2022) Ethiopia
Amir Ibrahim Ismail Emam
(Oct. 1, 2021 - Sep. 30, 2022) Sudan