1. 研究活動（2019年4月～2020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3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。令和元年12月6日には、スーダンとモンゴルから研究者3名を招き、第3回国際ワークショップを開催した。

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。

平成31年4月、乾燥地研究センターの木村玲二准教授が、2001年から2013年までを対象に全球の乾燥度指数を

1. Research Overview (April 2019–March 2020)

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 December 2019, ALRC held the 3rd International Workshop, inviting 3 researchers from Sudan and Mongolia.

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

ALRC's Associate Professor Reiji Kimura had examined changes of the global distribution of the aridity index calcu-

算出し、その研究成果が国際科学専門誌『Remote Sensing in Earth System Sciences』に掲載された。

令和元年7月、乾燥地研究センターが中心部局となり、鳥取大学とモンゴル科学アカデミー地理学・地生態学研究所との間で学術交流協定を締結した。

令和元年8月、スーダン農業研究機構のAdil Omer Salih Abdelrahim副長官を乾燥地研究センターに招聘し、SATREPSスーダンプロジェクトに係る打ち合わせを行った。

令和元年9月2日から9月13日に、インド・ニューデリーで開催された国連砂漠化対処条約第14回締約国会議（UNCCD／COP14）に、恒川教授が日本政府代表団の一員として参加したほか、国際乾燥地農業研究センター（ICARDA）・乾燥地研究センター・国際乾燥地研究教育機構の主催で「地域密着型の取組みによるレジリエンスと生計の向上」と題したサイドイベントを開催した。

令和2年1月、乾燥地研究センターの妻鹿良亮特命助教が、「節水型耐乾性」という新しいタイプの乾燥ストレス耐性を持つコムギに関する研究功績を高く評価され、鳥取大学長表彰を受賞した。

令和2年2月、乾燥地研究センターは独立行政法人国際協力機構中国センター（JICA中国）と共催で、特別イベント「フィリピンにおける糖尿病の現状と国際協力」を開催、併せて、写真展「フィリピンの文化と生活　糖尿病予防のための国際協力」を開催した。

乾燥地研究センターが平成30年度にライプニッツ植物遺伝作物学研究所（IPK、ドイツ）と研究協力に関する覚書を締結したことから、IPKがオーストラリア連邦科学産業研究機構（CSIRO、オーストラリア）を介して受託したビル＆メリンダ・ゲイツ財団のプロジェクトに、同センターの石井孝佳講師が参加した。令和元年度はササゲの動原体改変に関する研究を実施し、ゲノム編集を用いて動原体関連タンパク質の改変に成功した。

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5名、准教授5名、講師1名、特命准教授1名、特命助教1名、特任教授1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11名が配置された。事務系には職員17名（事務職員5名、事務補佐員12名）、技術系には職員9名（技術職員4名、技術補佐員5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2年3月31日時点）。

共同研究、教育、刊行物

令和元年度における共同利用研究代表者（大学教員など）は59名、指導学生数は37名（博士課程24名、修士課程8名、学部学生3名、研究生2名、うち留学生29名（中国7名、エチオピア11名、スーダン6名、ナイジェリア1名、

lated using the latest datasets from 2001 to 2013. It was published in an international journal of Remote Sensing in Earth System Sciences on April 22, 2019.

In July 2019, with ALRC being the central department, Tottori University entered into an agreement of academic exchange with the Institute of Geography and Geoecology, Mongolian Academy of Sciences, Mongolia,

In August 2019, ALRC invited Prof. Adil Omer Salih Abdelrahim, Deputy Director General of Agricultural Research Corporation (ARC), Sudan, and held meetings on SATREPS Sudan project.

ALRC participated in the UNCCD COP14 that was taken place in New Delhi, India in September 2019. ALRC's Professor Atsushi Tsunekawa took part in the conference as a member of the Japanese government delegation. ALRC held a side event entitled "Enhancing Resilience and Livelihoods through Community-based Actions" jointly with IPDRE and the International Center for Agricultural Research in the Dry Areas (ICARDA).

In January 2020, ALRC's Specially Appointed Assistant Professor Ryosuke Mega received the Tottori University President's Award for his highly-evaluated research achievements on wheat with a new type of drought stress resistance "water-saving drought tolerance."

In February 2020, ARLC and JICA Chugoku Center jointly organized a special event entitled "Current situation of diabetes in the Philippines and international cooperation" and a photo exhibition entitled "Culture and life in the Philippines: International cooperation for diabetes prevention."

As ALRC and Leibniz Institute of Plant Genetics and Crop Plant Research (IPK), Germany, signed a memorandum of scientific cooperation in FY 2018, ALRC's Junior Associate Professor Takayoshi Ishii participated in a project of the Bill & Melinda Gates Foundation commissioned by Commonwealth Scientific and Industrial Research Organisation (CSIRO) through IPK. In FY 2019, his research team conducted studies on cowpea kinetochore modification, and succeeded to modify kinetochore related proteins by using genome editing.

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, 2020, five full-time professors, five associate professors, one junior associate professor, one specially appointed associate professor, one specially appointed assistant professor, one specially appointed professor, four visiting professors from Japan and three foreign research scholars were allocated to these research divisions. In addition, 11 project researchers were added to our research teams. Moreover, 17 office staff (five full-time and 12 part-time) and nine technical staff (four full-time and five part-time) supported ALRC's research and education.

Joint Research, Education, Publication

In FY2019, 59 joint-use research principal investigators, mainly from national and private universities, were attached to ALRC. In addition, ALRC had a total of 37 students; 24 Ph.D. students, eight master's students, three undergraduate students and two research students. Of them, 29 students were from overseas; seven Chinese, 11 Ethiopian, six Suda-

南アフリカ1名、モンゴル1名、バングラデシュ1名、ケニア1名）)である。

共同研究に関する研究発表会は毎年開催しており、令和元年度は、12月7日～8日に本学において開催した。また、センター内外の乾燥地研究者によるセミナーも数多く開催されている。

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、令和元年度には、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. 4　乾燥地の塩類集積（鳥取大学乾燥地研究センター監修、山中典和、トデリッチクリスティーナ編、今井出版、令和元年3月出版）
- モンゴル放牧地の植物　第2版　第1巻、2巻（Undarmaa, J.、大黒俊哉、Nyamtseren, Z.、Manibazar, N., 山中典和編、Munkhiin Useg社、令和元年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。

令和元年度の主な活動は以下のとおり。

- 乾燥地研究センターの活動を紹介するパネル展：令和元年4月23日～5月13日、10月12日～11月5日、鳥取砂丘ビジターセンター
- 国連砂漠化対処条約第14回締約国会議（UNCCD／COP14）においてサイドイベント「地域密着型の取組みによるレジリエンスと生計の向上」開催：令和元年9月6日、インド・ニューデリー、主催：国際乾燥地農業研究センター（ICARDA）・乾燥地研究センター・国際乾燥地研究教育機構
- 東京理科大学主催の第11回坊っちゃん講座での中学生、高校生、大学生向け講演「健康被害、気候変動を引き起こす黄砂－その発生メカニズムの最新研究－」：令和2年1月11日、東京理科大学、講師：黒崎泰典准教授
- 特別イベント「フィリピンにおける糖尿病の現状と国際協力」（令和2年2月11日）、写真展「フィリピンの文化と生活、糖尿病予防のための国際協力」（令和2年2月9日～2月16日）：イオンモール鳥取北、共催：JICA中国
- 一般公開：令和元年7月21日、参加人数167名
- 子供向け体験学習コーナー（小学生向け実験イベント）：令和元年7月21日、参加人数24名

nese, one Nigerian, one South African, one Mongolian, one Bangladeshi and one Kenyan.

ALRC holds the Joint Research Symposium every year. In FY2019, we held the symposium on December 7 and 8 at the main campus of Tottori University. Seminars were often held by internal and external experts.

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 2019.

- Photobooks of Drylands vol.4: Salinization in Drylands (Supervision: ALRC, Yamanaka, N. and Toderich, K. eds. Published by IMAISHUPPAN, March 2020)
- Rangeland Plants of Mongolia Second edition Vol. I & II (Undarmaa, J., Okuro, T., Nyamtseren, Z., Manibazar, N. and Yamanaka, N., eds. Published by Munkhiin useg Co. Ltd., March 2020)

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.

We held the following activities during FY2019.

- Panel exhibition to introduce research activities of ALRC: April 23 - May 13, and October 12 - November 5, 2019, Tottori Sand Dunes Visitor Center
- UNCCD COP14 side event “Enhancing Resilience and Livelihoods through Community-based Actions”: September 6, 2019, New Delhi, India. Co-organizer: International Center for Agricultural Research in the Dry Areas (ICARDA), Arid Land Research Center (ALRC) and International Platform for Dryland Research and Education (IPDRE)
- Giving a lecture entitled “Asian dust causing adverse health effects and climate change: The latest research of its emission mechanism ” for junior high, high school and university students at the 11th Bocchan Lecture Series hosted by Tokyo University of Science: January 11, 2020, Tokyo University of Science, Lecturer: ALRC’s Associate Professor Yasunori Kurosaki
- Special event entitled “Current situation of diabetes in the Philippines and international cooperation” (February 11, 2020) and photo exhibition entitled “Culture and life in the Philippines: International cooperation for diabetes prevention.” (February 9 - 16, 2020): AEON MALL Tottori Kita. Co-organizer: JICA Chugoku Center
- Open House Event: July 21, 2019, ALRC
- Experimental event for elementary school students: July 21, 2019, ALRC

(2) 研究部門

1) 総合的砂漠化対処部門

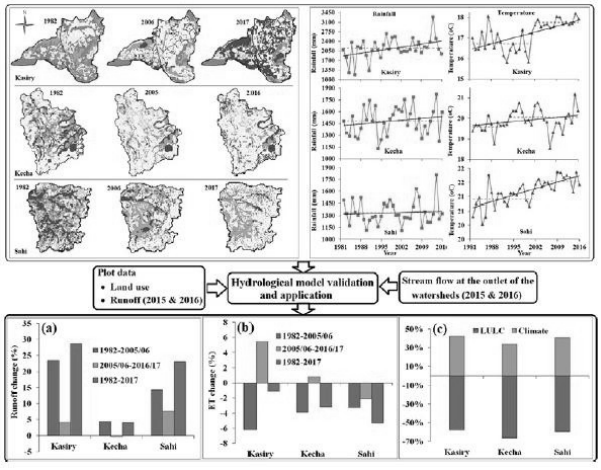
恒川 篤史（保全情報学）

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推定
３．乾燥地における持続可能性の評価手法の開発
４．バイオ燃料植物の生産力と環境影響の評価

本年度は、エチオピアの青ナイル川上流域における異なる農業生態学的環境における土壌・水保全対策の効果に関して以下の研究結果を得た。

3 つの調査流域での経験的モデルを検証した後、LULC の変化と気候変動が水文学的応答（年間の表面流出量と蒸発散量）に与える個別の複合的な影響を評価した。調査期間（1982～2016 年）で観測された LULC の変化により、Kecha 小流域の 4%から Kasiry 小流域の 28.7%の範囲で流出量が増加した。年間降水量に関する気候変動は、推定流出量に大きな影響を与えなかった。対照的に、蒸発散量は LULC の変化と気候変動の両方の影響を受けた。気候変動により、蒸発散量が Kecha で 33.6%、Kasiry で 42.1%増加したが、自然植生の減少に関連する LULC の変更により相殺効果があり、Kasiry で 15.8%、Kecha で 32.8%蒸発散量が減少した。全体として、流域の水文応答は、土地の使用方法と管理方法によって主に制御され、気候変動の影響を緩和または悪化させた。



• Land use/land cover change caused higher surface runoff and lower evapotranspiration.

• Climate variability increased evapotranspiration in all three watersheds.

• Land use/land cover change had a dominant role in the hydrological responses.

(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. Evaluation of productivity and environmental impacts of biofuel plants

We obtained the following research findings about efficiency of soil and water conservation practices in different agro-ecological environments in the Upper Blue Nile Basin of Ethiopia.

Land use/land cover (LULC) change and climate variability are two major factors controlling hydrological responses. The present study analyzed the separate and combined effects of these two factors on annual surface runoff and evapotranspiration (ET) after validating the selected models in three drought–prone watersheds of the Upper Blue Nile basin: Kasiry (highland), Kecha (midland), and Sahi (lowland). During 1982–2016/17 the area covered by natural vegetation showed dramatic decreases, ranging from 60.2% in Kasiry to 51.8% in Sahi. In contrast, increases in cultivated land ranged from36.7% in Kasiry to 279.6% in Sahi; the smaller increase in Kasiry resulted from the conversion of a portion of the cultivated land to an Acacia decurrens plantation after 2006.The observed LULC changes over the study period resulted in runoff increases ranging from4% in Kecha to 28.7% in Kasiry. Climate variability in terms of annual rainfall had no significant effect on estimated runoff; whereas both LULC change and climate variability had significant effect on estimated ET. Though climate variability increased ET from 33.6% in Kecha to 42.1% in Kasiry, the LULC change related to the reduction in natural vegetation had an offsetting effect, which led to overall decreases in ET ranging from15.8% in Kasiry to 32.8% in Kecha watershed. As changes in LULC and climate are expected to intensify in the future, it is important to study further hydrological responses considering these changes to devise future sustainable land and water management strategies.

[Berihun, M.L., Tsunekawa, A., Haregeweyn, N., Meshesha, D.T., Adgo, E., Tsubo, M., Masunaga, T., Fenta, A.A., Sultan, D., Yibeltal, M., Ebabu, K. 2019. Hydrological responses to land use/land cover change and climatevariability in contrasting agro-ecological environments of the Upper BlueNile basin, Ethiopia. Science of the Total Environment 689: 347–365.]

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

2019 年度は、次の研究を行った。

南アフリカにおける牧草生産の衛星リモートセンシング

衛星リモートセンシング技術は、草地の生産性のモニタリングに用いられるが、枯れた植物の現存量に関する研究は少ない。本研究では、牧草の緑色部分と非緑色部分を区別することができる衛星リモートセンシング手法を提案した。MODIS 衛星データを用いて、南アフリカの乾燥草地における緑色現存量と正規化差植生指数（NDVI）の関係および非緑色現存量と正規化差水指数（NDWI）の関係を明らかにした。これにより、牧草生産の過小評価を最小限にすることができる。本年度は、MODIS 衛星データから算出される植生指標を用いて、地上部バイオマス推定の回帰モデルを開発した。

スーダンの灌漑コムギ圃場における微気象観測

スーダンの高温乾燥下で栽培される灌漑コムギ圃場における微気象観測を開始した。本研究では、灌漑コムギのキャノピー表面温度と 2 メートル高の気温の関係を明らかにし、キャノピー表面温度推定の微気象モデルシミュレーションを行う。今年度は、スーダン農業研究機構・ワドメダニ試験場の灌漑コムギ圃場において、出穂から登熟まで微気象観測を行った。

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.

Satellite remote sensing of pasture production in South Africa

Satellite remote sensing technology has been successfully used to monitor grassland productivity, but senescent standing plant biomass has not been widely studied. This study proposed a satellite remote sensing method that can distinguish between green and non-green herbage. MODIS satellite data were used to develop relationships between green aboveground biomass and Normalized Difference Vegetation Index (NDVI) and between non-green aboveground biomass and Normalized Difference Water Index (NDWI) in South African semi-arid grasslands. This in turn can minimize underestimations of pasture availability in the semi-arid grasslands. In this fiscal year, a regression model for estimation of aboveground biomass was developed using vegetation indices calculated from MODIS satellite data.

Micrometeorological observation in an irrigated wheat field in Sudan

We began micrometeorological observation in an irrigated wheat field grown under hot and dry conditions in Sudan. The objectives of this study are to understand the relationship between canopy surface temperature and air temperature at 2 m height and then to carry out micrometeorological model simulation for estimation of canopy surface temperature. In this fiscal year, the micrometeorological observation was carried out during the period from heading to maturity in the irrigated wheat field at the Wad Medani station of Sudan Agricultural Research Corporation.

An irrigated wheat field in Sudan (Feb. 2020)

Micrometeorological observation in Sudan (Feb. 2020)

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。

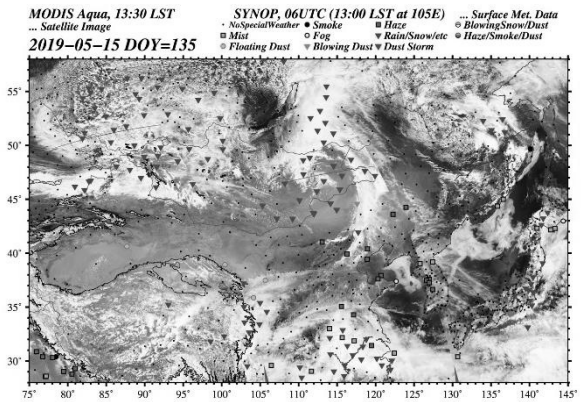
課題(1)では、気象台データと MODIS 衛星画像を用いた東アジア準リアルタイムダストモニタリングシステムの維持更新を行い、ダスト発生・輸送経路の議論に用いた。

課題(2)では、2012 年 3 月にゴビ砂漠北部のツォクトオボー（モンゴル）に設置した観測設備を用いて、黄砂発生メカニズム解明のための観測を実施した。乾地研共同研究（代表：石塚正秀・香川大）などにおいて、土壌水分と土壌クラスト強度の関係を定量評価するための室内実験を実施した。Buyantogtokh 氏（D1, 連合農学研究科）、Wu Jing（プロジェクト研究員）とレキ被覆、枯れ草の分布及び飛砂への影響の研究を推進した。

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。この観測において、課題(1)で作成した衛星画像を観測日特定に活用した。課題 1〜3 を繋げるため、乾地研共同研究(代表：関山剛・気象研究所)などにおいて、Buyantogtokh 氏等と数値モデルを用いた黄砂発生・輸送の研究を推進している。

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）の研究を進めている。

これらは、日本学術振興会科学研究費（課題番号 25220201, 17H01616）、乾燥地×温暖化プロジェクト、鳥取大学国際乾燥地研究教育機構経費、乾燥地研究センター共同研究において実施した。



Dust distribution on May 15, 2019. This image was produced by the near-real time east Asia dust monitoring system.

Yasunori Kurosaki (Assoc. 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 works as a factor of health impact such as respiratory disease and as a factor of environment change such as neutralization of acid rain, marine ecosystem change, climate change, 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 and meteorological observatory data was operated. The images were utilized for discussion of emission places and transportation routes of dust with research colleagues.

On the subject (2), observations were carried out to elucidate dust emission mechanisms utilizing the dust monitoring system, which was installed at Tsogt-Ovoo, Mongolia located in a northern part of the Gobi Desert. Laboratory experiments were carried out to measure a hardness of soil crust under ALRC joint research (PI: Prof. Ishizuka, Kagawa Univ.) etc. Field surveys and numerical simulations were conducted to elucidate effects of stone and dead vegetation on sand saltation with Mr. Buyantogtokh (D1, the United Graduate School of Agricultural Sciences) and Dr. Wu Jing (Project Researcher).

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.). To connect subjects 1-3, a research using numerical dust model was carried out under ALRC joint research (PI: Dr. Sekiyama, Meteorological Research Institute) with Mr. Buyantogtokh.

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 JSPS KAKENHI (Grant Numbers 25220201 and 17H01616), by Project ICC×DRYLANDS, by International Platform for Dryland Research and Education (IPDRE), and by ALRC joint researches.

A view of field survey for dead vegetation, Tsogt-Ovoo (September 2019).

小林　伸行（社会経済学）

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、以下の取り組みを実施した。

１．中国・蘭州大学との共同研究

乾燥地で一般的な飼料を用いて、反芻家畜の消化管内発酵で生じるメタン排出量の抑制と、そのエネルギー収支の改善を図るための牛の飼養試験を行なう。これに先立ち、メタン排出量の簡易な測定方法を構築すべく、同大学が保有する開放型呼吸試験装置を用いてレーザー式メタン検知器（携帯型）の活用可能性を検証した。

２．エチオピア「次世代型・持続可能な土地管理フレームワークの開発」（JICA/JST 科学技術協力事業）

同国青ナイル上流域で標高が異なる 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、舎飼い飼養での飼料設計の改善案を提示する。このため、3 小流域で入手可能な飼料の栄養価を評価、舎飼い飼養における有望草種を選定し、これら草種を用いた乳牛の飼養試験を実施した。レーザー式メタン検知器を活用することで、メタン発生量を抑制しながら乳量を最適化するための飼料設計案を提示することができた。

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（JICA 草の根事業による一部支援；2020 年 1 月終了）」において、患者リーダー及び地域保健師による糖尿病自己管理のための普及啓発活動を支援しつつ、これまでの活動成果を把握するため、糖尿病患者向け健診を行なった。その結果、患者の健康状態を把握する指標としての血中 HbA1c 値の活用は、活動対象地区（マニラ首都圏パテロス町）の患者が自律的・継続的に計測（モニタリング）するうえで資金面での課題が大きいことが判明したため、これに代わる指標（血糖値の日内変動等）の活用・普及可能性を検証することとした。

Kobayashi Nobuyuki (Associate Prof., Sociology/Economy)

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. In this regard, the following activities were implemented in 2019.

1. Collaborative research with Lanzhou University in China

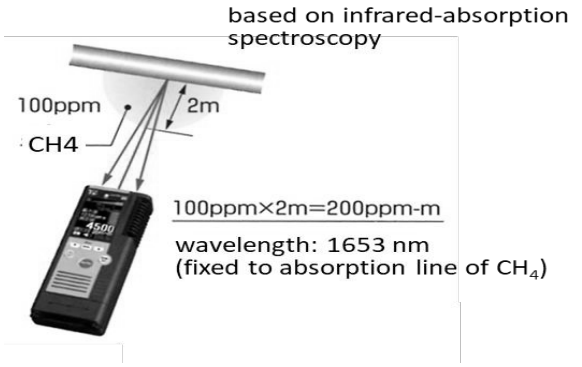
Feeding trials for cattle, which aims to improve its energy utilization and to mitigate methane (CH_4) emissions caused by the gastrointestinal fermentation, using the feed resources easily available in the drylands, were scheduled. Prior to the trials, we validated the use of portable CH_4 detector to estimate the CH_4 emissions, using the open-circuit respiration chambers in Lanzhou University.

2. Research for 'the Project for development of sustainable land management framework' funded by JICA/JST in Ethiopia

This activity aims to improve feeding design for confined beef/dairy cattle to prevent the degradation of pasture land due to overgrazing and for effective animal production in the 3 watersheds of Upper Blue Nile basin. In 2019, we analyzed nutrient composition of potential feed resources in the watersheds, and selected expected forage species. Using these species, the trials for local dairy cows were carried out. Application of the portable CH_4 detector in the trials enabled us to propose some optimal feeding designs to mitigate CH_4 emissions and improve milk yield.

International Cooperation:

Most technologies for drylands are applied in developing countries. Activities for development in these countries are important. The Project for enhancing the preventive measures for diabetes in Philippines (partially funded by JICA) supported extension for diabetes self-management by the patients' leaders and the local health professionals. Through the medical check-up to monitor effects of the extension activities, we recognized the use of HbA1c to monitor the patient's health conditions were not optimum, as monitoring HbA1c by the patients and local professionals was financially challenged. We will study the possibility to introduce the alternative monitoring indicators and to establish the management system for monitoring. These project activities were introduced to public in the event by JICA and Tottori University in Tottori-city.



Mechanism of laser methane detector to measure the methane plume exhaled from the animal's nostril

Collaborative event of JICA and Tottori University to introduce the activities in Philippines (in Tottori-city)

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 less privileged segment of the society (landless youth and women) in land management through 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. Since the 1970s, the successive governments of Ethiopia have been implementing "participatory" watershed development programs through promoting spectrum of sustainable land management technologies to curb the effects of land degradation in the highland areas. However, I found that these intervention programs were less participatory, in terms of involving the actual users of land resources in programs planning and implementation decisions. In addition, actual implementation of these programs have failed to consider small-scale farmers' potential willingness to contribute for sustainable land management practices, as well as basic biophysical, socioeconomic, and institutional factors. Accordingly, in this study, I estimated the small-scale farmers' potential willingness to contribute (in terms of labor) and analyzed the drivers behind it in the drought-prone highland areas of north western Ethiopia. A double-bounded contingent valuation method and Tobit econometric model were used to analyze survey data collated from 300 farming household heads selected from three watersheds (Aba Gerima, Guder and Dibatie watersheds) in the Upper Blue Nile basin, Ethiopia. A little higher than three-fourth of the farmers indicated that they would be willing to contribute labor (3.5–28 man-days yr^{-1}), however, the average value of their willingness to contribute (9.4 man-days yr^{-1}) was almost only one-third of the government's expected contribution (28 man-days yr^{-1}). The farmers' willingness to contribute aggregate benefit values at the watershed scale was estimated to be US$55,572 yr^{-1}. The econometric model results revealed that sex, age group, farmland size, sustainable land management-related trainings, and household perception of land degradation influenced farmers' potential willingness to contribute. To this end, I recommended revisions in the current watershed development scheme by considering various aspects of farmers' contribution on willingness basis would help to make the scheme demand-driven. Moreover, the provision of gender and resource-disaggregated trainings and the introduction of economic incentives to increase the economic productivity of sustainable land management practices would enhance farmers' maximum willingness to contribute capacity and assure sustainable community participation.
2. Land degradation in drought-prone highlands of Ethiopia is the primary problem affecting livelihoods of rural communities, in general, and for those disadvantaged section of the community (e.g., landless youth and women), in particular. The livelihood of the majority of households relies on agriculture-based income which is dependent mainly on the exploitation of scarce natural resources. Moreover, unless non-agricultural sectors of the economy are not able to siphon excess rural labor, the rapidly growing population is expanding agricultural activities (crop cultivation and livestock grazing) towards marginal and fragile lands, which will further contribute to a high level of land degradation, low productivity, and greater poverty and social disparity. As a result, poor rural people are ill-equipped to efficiently respond to environmental and livelihood shocks and stresses (e.g., scarcity of land, lack of income and limited opportunities) they are persistently exposed to. My hypothesis here is that, "land degradation occurs due to people's inability to access the resources that would allow them to derive their livelihoods in an environmentally sustainable way, and its effect is disproportionately higher for rural poor people (particularly women and youth)." Therefore, poor farmers' engagement 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, participation in value chain) would allow them to reduce poverty and social disparity, at the same time, protect and restore the environment on which they depend. In Guder watershed, the income generating activity being promoted include small-scale improved poultry production (i.e., promotion of improved poultry production system through improved breeds, housing, feed and feeding management, biosecurity and health management, use of chicken droppings as manure fertilizer for vegetable production) (Fig. 1).

Fig. 1 An income generating activity beneficiary of SATREPS Project while taking care of her chickens.

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、スーダン等にある研究機関、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、特に以下の研究で成果を得た。

1．2020 年 3 月、モンゴル生命科学大学（旧モンゴル農業大学）のウンダルマ先生、マニバサル先生、ニャムツェレン先生、そして東京大学の大黒先生とともに、「モンゴルの放牧地植物 vol. 1，2」の第 2 版をモンゴルで出版した。第 2 版は第 1 版に比べ大幅に掲載種を増やす（396 種から 512 種へ増加）と共に、第 1 版出版後の知見も反映したものとなっている。また、第 1 版同様、モンゴル語と英語で作成しており、今後も、モンゴルの研究者、放牧地管理者、そしてモンゴルの未来を担う若い学生たちのテキストとして、モンゴルの持続可能な放牧地管理に役立てられるものになっている。

2. 2020 年 3 月、鳥取大学国際乾燥地研究教育機構のトデリッチ・クリステイーナ博士と共著で「乾燥地の塩類集積」を出版した。本書は、乾燥地の重要な環境問題である「塩類集積」に焦点をあてたもので、塩害問題が深刻な中央アジアの国々で活動を続けている多くの研究者の方々の協力を得て作られた。また、本書は国連砂漠化対処条約（UNCCD）のナレッジハブに掲載され、またライブラリにも登録された。

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, Sudan etc. and those in Japan. In this fiscal year, I obtained results from following researches:

1. In March 2020, the second edition of "Rangeland plants of Mongolia Vol. 1, 2" was published with Professors Undarmaa, Manibasar and Nyamtseren of the Mongolian University of Life Sciences and Prof. Okuro of the University of Tokyo. This book includes a significant increase in the number of species (from 396spp. to 512spp.) compared to the first edition, and also reflects the findings obtained after the first edition was published. As with the first edition, the book was prepared in Mongolian and English, and as a textbook for Mongolian researchers, rangeland managers and young students, it will be useful for sustainable rangeland management in Mongolia.

2. In March 2020, the Photobooks of drylands Vol. 4 "Salinization in Drylands" was published in collaboration with Dr. Toderich Kristeina of the IPDRE, Tottori University. This book focuses on "salt accumulation", an important environmental problem in the drylands. The book was included in the Knowledge Hub of the United Nations Convention to Combat Desertification (UNCCD) and added to the library of UNCCD.

Rangeland plants of Mongolia Vol. 1(left) and 2(right) published in Mongolia (Mar. 2020)

Publication of the Photobooks of drylands Vol. 4 "Salinization in Drylands" (Mar. 2020).

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
・スーダンにおけるソルガムに有用な微生物の探索

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。

微生物の機能をより詳細に調べるためには、対象の微生物を培養する必要があるが、分離培養できる微生物は限られている。また、どのような微生物が分離培養できて、どのような微生物が分離培養できないのかに関する情報は限られている。この点について情報を得るため、アメリカの調査地から採取した土壌を希釈した処理区、あるいは土壌水分の異なる処理区を設け、3 か月間植物を育成した。サンプリングにあたっては、植物の地上部、地下部バイオマスを測定するとともに、根の一部を DNA サンプルとして保管した。残りの根の一部は内生菌、および内生細菌の分離培養に供試した。内生細菌は湿潤と乾燥のいずれの処理区においても根に分布していることが確認されたが、内生菌については、湿潤処理区では根からほとんど菌類が分離できない植物個体もあり、乾燥条件下で菌類の根への感染が高いことが推察された。内生菌は 2000、そして内生細菌については 4000 を超える菌株が得られた。今後は、これらの分離菌株の種レベルでの分別と種推定を行う。

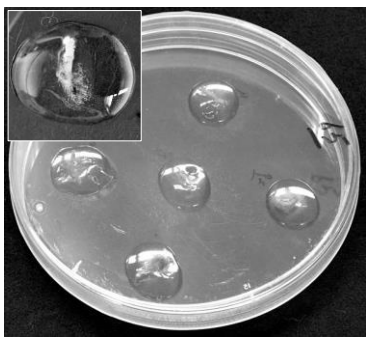
Takeshi Taniguchi (Assoc. Prof., Microbial Ecology)

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.

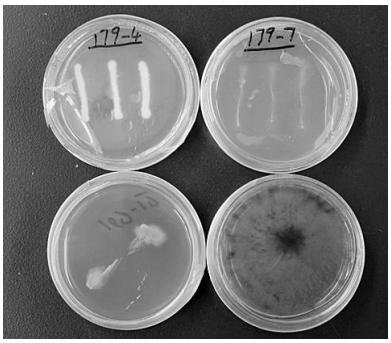
・Plant-microorganism symbiotic relationship under stressful conditions and the application to ecosystem restoration
・Exploration of useful microbial composition for plants under stressful conditions
・Search for the effective microbes of sorghum in Sudan

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:

To examine the microbial function, cultivation of target microbes is required, but culturable microbes is limited. Also, information on culturable and unculturable microbes is not clear. Here we grow plants under different conditions varying soil dilution and soil water content. After the 3-month growth periods, plant shoot and root were harvested, then a part of roots was used for isolation of microbes and metagenome analysis. In the isolation of microbes, endophytic bacteria exist both dry and wet soil conditions, whereas endophytic fungi were rare on some roots grown under wet soil condition. It indicates that the colonization of endophytic fungi is higher under dry soil condition. By the experiment, more than 2000 and 4000 endophytic fungal and bacterial isolates were obtained, although further classification of the isolates into species will be needed in next fiscal year.



Isolation of fungi from root fragments



Isolated fungi and bacteria

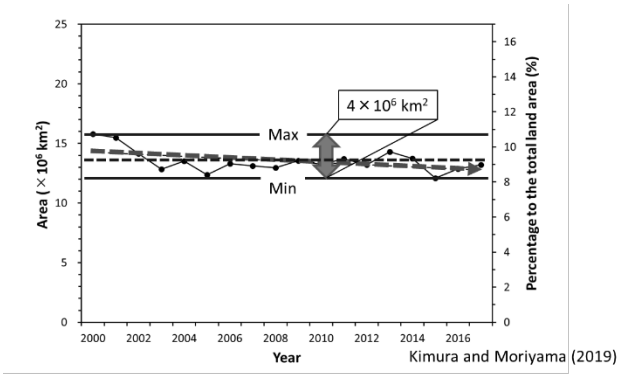
木村　玲二（気象学）

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 17H04634、17H01626、18K05877、19H04239）、宇宙航空研究開発機構(JAXA)の Global Change Observation Mission の援助(RA1C127)等により、主として中国やモンゴル、エジプトで行われている。以下に研究結果を示す。

1. 2001～2013 年を対象に、近年の全球の気候学的乾燥度分布を衛星データと気象データから算定される乾燥度指数を用いて作成し、UNEP による 90 年代の分布と比較した。その結果、乾燥地の中でも湿潤な地域がより乾燥し、半乾燥地や乾燥半湿潤地の面積が減少、しかしながら乾燥地全体の面積は 90 年代と変化がないことを明らかにした。
2. 2000～2017 年を対象に、全球の実際の乾燥度分布を衛星データのみから算定されるオリジナル指標「Satellite based Aridity Index (SbAI)」を用いて作成した。実際の乾燥地全体の面積は 1 による気候学的乾燥度指数を用いた面積と同じであるが、乾燥地の中でも極乾燥地の割合が多く、半乾燥地や乾燥半湿潤地の面積が減少していることが示唆された。
3. 2000～2017 年を対象に、乾燥地における土地劣化（砂漠化）面積の経年変化を衛星データから算定した。その結果、砂漠化面積は年々減少傾向にあり、この 18 年間で 4×10^6(km^2)減少していることを明らかにした。
4. SYNOP 気象データと衛星による放射温度、熱収支 2 層数値モデルを用いて、黄砂発生の臨界風速をシミュレーションする方法を構築した。これによって、受食性の要因となる土壌水分の閾値を SYNOP 気象データによって決定することが可能になる。
5. 直径 1㎝の圧電素子を用いた小型軽量飛砂計を用い、「砂漠化監視に特化した計測システム」用に鉛直フラックスを観測できるよう試作・改良した。その結果、飛砂が発生する高さ 30㎝ 以内で、理想的な飛砂量の鉛直分布の観測値を得ることに成功した。



Yearly change of global degraded area from 2000 to 2017.

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 17H04634, 17H01626, 18K05877, 19H04239), and JAXA Global Observation Mission (RA1C127), especially in China, Mongolia, and Egypt. I obtained results from following researches:

1. We examined changes of the global distribution of the aridity index (AI) calculated on the basis of meteorological reanalysis and precipitation datasets from 2001 to 2013. Climatically wet regions in arid regions are becoming more arid. These results suggest that land aridification or wetting can be detected by comparing the SbAI (=actual conditions) with the AI (=climatic conditions).
2. We used a satellite-based aridity index (SbAI) to investigate global changes of land surface aridity from 2000 to 2017. Degraded land areas were identified by using SbAI and the normalized difference vegetation index (NDVI). Here, degraded land include existing desert and the land having both permanent and temporal dust erodibility. Our results showed that actual land condition by SbAI became dryness than that derived from the climatic AI indicator in arid, semi-arid, and dry sub-humid regions and that the dryness was reflected in an increase in the extent of areas classified as hyper-arid. From 2000 to 2017, however, the annual extent of the wetter areas within arid regions (semi-arid and dry sub-humid regions) increased, and that of drier areas (hyper-arid and arid regions) decreased.
3. The global area of degraded land decreased slightly between 2000 and 2017, and the annual average area for that period was 13.5×10^6 km^2 (9.2% of total land area).
4. A method is proposed to estimate the threshold wind speed for dust emissions as a function of soil moisture in arid regions. This method, which is applicable at the local scale, employs a model of the surface heat budget to estimate the spatial distribution of thermal inertia-derived soil moisture (TISM) and an analytical footprint model to estimate dust source areas. It incorporates readily available satellite and SYNOP meteorological data.
5. We developed the compact light weight blown sand meter using piezoelectric device for vertical sand flux. These will be installed to the system for the desertification monitoring. The results indicated that ideal vertical sand flux was obtained within 30 cm in the wind tunnel experiments.

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ている。この情報から、ストレス耐性植物を選抜するために、特定の物質をバイオマーカーとして用いることを検討している。

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 wildlife 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 desiccation and heat stress in terms of gene expression and metabolite production profiles. Based on this information, we are trying to find specific substances that can be used as biomarkers for selection of stress-tolerant varieties.

SATREPS-wheat program conducting with wheat researchers in Agricultural Research Corporation in Sudan

Detailed analysis of stress response using growth chamber in Arid Land Research Center

藤巻　晴行（乾燥地灌漑排水学）

乾燥地灌漑排水分野では、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 の対策に取り組んでいる。昨年度は、主として以下の研究に取り組んだ。

１）限界地プロジェクト予算による「パレスチナ西岸地区におけるウォーターハーベスティングによる食料安全保障の強化」。ラマラ市郊外の傾斜地でビニールシートと貯水槽を用いたウォーターハーベスティングシステムを設置し、自動灌漑栽培実験を行った。

２）国際乾燥地研究教育機構予算による「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」。パレスチナ農業研究所ジェリコ支所内の実験圃場にて灌漑実験を行った。

３）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。スーダンとモロッコとセンター圃場で小麦を供試作物とする灌漑実験を行った。

４）エチオピア SATREPS における「青ナイル川流域の斜面における遮水シートを用いた天水田栽培」

５）住友ゴムとの共同研究「ラテックス遮水膜を用いた土壌の保水性向上検討」。根群域の下端まで掘って水平面を造成し、その上に多孔ラテックスゴム膜を作成し、その上に再び作土を覆土することで根群域の保水性を高める方法を考案し、その効果を検証した。

６）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

７）ユニチカとの共同研究「不織布を用いた Dehydration 法による除塩効果の検証」。ウズベキスタンのアラル海流域国際イノベーションセンターの実験圃場で予備実験を行った。

また、主として以下の海外活動を行った。

１．課題 1, 2 の遂行のためのパレスチナ出張（3 回、延べ 20 日）
２．課題 3 の遂行のためのスーダンおよびモロッコ出張（2 回、延べ 15 日間）
３．課題 4 の遂行のためのエチオピア出張（2 回、延べ 13 日間）
４．課題 7 の遂行のためのウズベキスタン出張（3 回、延べ 20 日）

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. The main research activities in the fiscal year were as follows:

1. “Enhancing Food Security using water harvesting in West Bank of Palestine” as an activity of husbandry group under the “Project Marginal Land”. Experiments of water harvesting system using a plastic sheet and reservoir in a slope in suburb of Ramallah was carried out.
2. “Optimizing trigger suction for automated irrigation system for Date Palm in Palestine”, as an activity under IPDRE, being carried out in Jericho station of National Agricultural Research Center.
3. 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 ALRC, Sudan and Morocco.
4. “Rain-fed rice cultivation using a geo-membrane on a hill site in Blue Nile Basin” as an activity of the SATREPS in Ethiopia.
5. Enhancing water holding capacity using a low peameable layer made from latex as a cooperative research with Sumitomo Rubber Industry. Low peameable layer was formed at the depth of 30 cm in the experimental field of ALRC and soil moisture above the layer was observed.
6. Water and salinity management for a sand-ponics and an upward irrigation system. Irrigation experiment using Melon was carried out in ALRC.
7. Evaluation of salt-removal effect of the dehydration method using non-woven sheet” as a cooperative research with Unitika. A preliminary experiment was carried out in an experimental farmland in the International Innovation Center for Aral Sea Basin.

Overseas research activities during the fiscal year were:

1. visits to Palestine three times for topic 1 and 2.
2. visits to Sudan twice for topic 3
3. visits to Ethiopia twice for topic 4.
4. visits to Uzbekistan for topic 7.

Irrigation experiment for wheat in Dongola, Sudan

Removing salts using cotton sheets in Uzbekistan

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. コムギにおける DELLA タンパク質の気孔調節機構の解明。
5. 中国の砂漠と砂漠化地域における植物の分布調査。
6. 根の細胞壁の化学性・物理性と作物の耐塩性の関係の解明。

本年度、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を訪問し、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および塩生植物栽培実験の結果について、現地研究者と検討した。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を視察し、問題について共同研究の展開を検討した。中国河北省林業科学院も訪問し、共同研究である乾燥砂地植林に用いられる長根苗の成長に関する生理学的反応を調査した。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。

下の写真に調査地の様子を示した。

Halophyte of *Suaeda salsa* grown in saline soils along Bohai Bay in China

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. Mechanisms of DELLA protein on adjusting stomata opening in wheat;
5. Vegetation distribution in the desertified areas of China;
6. Relationship between the chemical and physical characteristics of root cell wall and salt tolerance in crops.

The main research activities during the fiscal year 2019 include a visit to 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 halophytes cultivation experiments were discussed with local researchers. Cooperation on a greening project in saline soils was initiated. A visit to Hebei Academy of Forestry. Responses of long-root trees used for sandy lands greening were investigated. Studies of the relationship between root physical and chemical characteristics and plant salt tolerance were continually carried out.

Cotton cultivation in saline soils in Nanpi County, 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）CRISPR/Cas9 システムの細胞遺伝学的な応用法の開発

（3）コムギの新奇遺伝資源の創設

これらの研究は、ライプニッツ植物遺伝学研究所（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）、福井県立大学の（松岡由浩）との共同研究で行われている。

本年度は、特に以下の研究で成果を得た。

1. ササゲ（Vigna unguiculata、2n = 2x = 22）は、アフリカでは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。 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 CENH 3 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 の改変に成功し、世界で初めて生物が持つ 2 種類の CENH3 の機能を遺伝子破壊によって証明した。本成果は現在国際ジャーナルに投稿中である。また、400 系統を超えるササゲの遺伝資源を本センターにおいての栽培を開始した。
2. CRISPR/Cas9 によるゲノム編集技術を応用することで、核および染色体の任意ゲノム領域を可視化する新しい技術を 2018 年に開発し、RNA-guided endonuclease - in situ labelling（RGEN-ISL）法と命名した。今年度は RGEN-ISL 法、免疫染色法、DNA の複製の領域を特定する手法と同時に行い、DNA 配列、タンパク質、DNA 複製の 3 種類の異なる情報を一度に取得する事に成功した。また、ゲノム編集技術の応用による動植物における新たな細胞遺伝学の技術革新に関する総説をまとめた。本研究成果は Chromosome research, Cytogenetic and Genome Research に掲載された。
3. 松岡由浩を代表とする（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）に参加し、国際トウモロコシ･コムギ改良センターに赴き、新奇コムギ遺伝資源の創出に向け多数のコムギと野生種の交雑を開始した。

Flower color is different in cowpea and cowpea wild species.

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) Further development of new cytogenetic tool with CRISPR / Cas9 system

(3) Creation of novel genetic resources for wheat

The international collaboration project was made possible through a grant to The University of Queensland (Australia) by the Bill & Melinda Gates Foundation (USA) as well as through funding by the German Research Foundation DFG (Germany). JSPS funding through the Yoshihiro Matsuoka (Japan). In this fiscal year, I obtained results from following researches:

1. Cowpea (*Vigna unguiculata*, 2n=2x=22) is an important legume crop in Africa, and has a pronounced tolerance to drought and heat stress. Haploids (doubled haploids) are very instrumental to accelerate the plant breeding process. We intend to establish a haploid production method for cowpea via manipulation of the centromere-specific histone H3 (CENH3) variant. Cowpea encodes two types of CENH3s in the diploid genome. We succeeded in editing CENH3s with CRISPR/Cas9 and demonstrated the functions of two different kinds of CENH3s in cowpea. This work is currently being submitted to an international journal. In addition, over 400 cowpea genetic resources have been cultivated at Arid Land Research Center.
2. Development of a new molecular visualization method, RNA-guided endonuclease - *in situ* labelling (RGEN-ISL) for the CRISPR/Cas9-mediated labelling of genomic sequences in nuclei and chromosomes. RGEN-ISL, immunostaining, and visualizing the DNA replication place were performed at the same time in plants. We succeeded in obtaining three different types of visualizing information of DNA sequence, protein, and DNA replication at once. We have summarized a review of new technological innovations in cytogenetics in plants and animals through the application of genome editing technology. The results of research were published in Chromosome research, and Cytogenetic and Genome Research.
3. Participated in the JSPS research project through the Yoshihiro Matsuoka, we visited the International Maize and Wheat Improvement Center (CIMMYT), and started crossing bread wheat and wild species to create novel wheat genetic resources.

Spikes of bread wheat, wild relatives of wheat, and synthetic wheat. There are many useful traits that are not used in wheat in wild relatives.

Yasir Serag Alnor Mohammed (Yasir Gorafi, Specially-Appointed Assoc. Prof., Molecular Breeding)

The research activities from April 2019 to March 2020 included the study of wheat tolerance to salinity stress.

In arid and semi-arid regions, vast agricultural lands are affected by salinity. Previously, we tested 247 multiple synthetic derivatives lines under a combined heat-salinity stress in Sudan. We observed a wide genetic variation in response to the stress. Out of these 247, we selected and evaluated 130 lines under control and salinity stress in the field of the International Center of Biosaline Agriculture, Dubai, UAE. The objective was to confirm the results of the previous study and to identify lines tolerant to salinity. In the control plots, lines were irrigated with normal water throughout the season. In contrast, in the salinity plots, lines were irrigated with saline water of 15 ds/m (Fig. 1). Data were collected on various morphological and physiological traits.

The genotypes responded differently in the two treatments. The canopy temperature showed a highly significant difference between the two treatments (Fig. 2). Under the saline irrigation, the lines had higher canopy temperature than under the non-saline irrigation. These findings suggest that canopy temperature could be used as selection criteria to identify tolerant genotypes under salinity stress. However, this result need to be confirmed in multiinvironment experiments.

Under both conditions, grain yield associated positively with biomass, grain number and grain weight, and negatively with heading and maturity dates.

Regression analysis of the relationship between the grain yield of the control treatment and the grain yield of the salinity treatment was performed to identify the potential genotypes and to select the best genotyeps (Frig. 3). Based on the analysis, some lines were tolerant with high yeidl potential, some other lines were tolerant with good yield and others were tolerant with low yield. The identified genotypes will be used to understand the mechanism of the tolerance and breeding

I had one publications and two overseas research visits to Sudan, Agricultural Research Corporation.

Fig.1 The tested lines growing under the fresh and the saline water

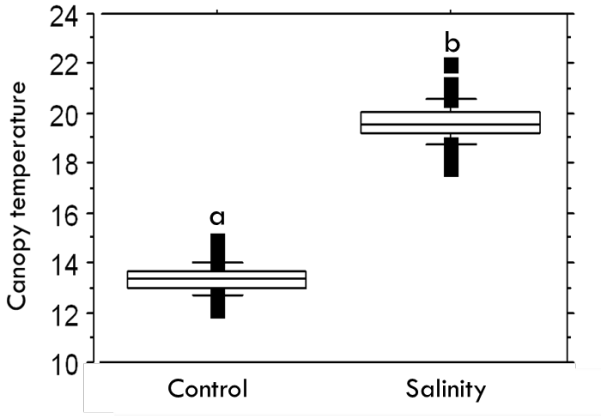


Fig. 2 The canopy temperature of 130 bread wheat lines evaluated under control and salinity

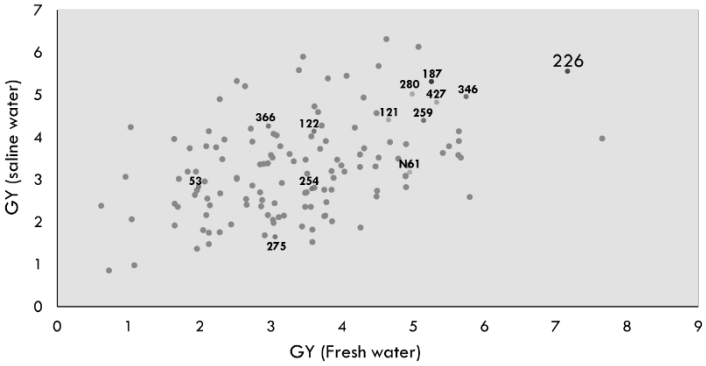


Fig. 3 The relationship between the grain yield under the control (fresh water irrigation) and the salinity (saline water irrigation).

妻鹿　良亮（植物生理・分子生物学）

世界の陸地の約 4 割が年間降雨量の少ない乾燥地である。乾燥地では現行の作物品種では栽培が難しく、品種改良によって栽培を可能にすることは、世界的に逼迫してくる食糧問題の解決に大きく貢献できる。植物の耐乾性の向上はこの問題を解決することができる重要なアプローチの一つである。

植物の耐乾性にはアブシジン酸 (ABA) が密接に関わっており、ABA 受容体の過剰発現により ABA に対する感受性が高まり、耐乾性が向上する。ABA は植物に普遍的に存在する適合溶質の一つであり、耐乾性作物の創出には ABA 受容体の利用と応用が適していると考えられる。本研究ではこれまでにコムギの ABA 受容体 (TaPYL) の同定、TaPYL を過剰発現したコムギ (TaPYLox) の開発を行い、TaPYLox が「節水型耐乾性」というこれまでになかったタイプの乾燥ストレス耐性を持つことを発見した。そこで、本年度では、節水型耐乾性コムギが示す形質のうち、炭素同位体比分析による生育期間全体での蒸散活性を評価することで、自然交配系統からの節水型耐乾性あるいは耐暑性コムギを選抜するため、スーダンの圃場にて試験を行い、候補系統の選抜を行った。

本年度は、特に以下の研究で成果を得た。

1. スーダン農業研究機構において灌漑による水の供給量を調節した圃場にて、160 系統の多重合成コムギ派生集団を用いた耐乾性試験を行なった。種子収量や出穂までの日数をはじめとした農業的形質データを収集した。
2. IR-MS を用いた炭素同位体比分析によって節水性系統を耐暑性系統の選別を行った。節水性系統は蒸散活性が低く、炭素同位体比の値が高い傾向にある。一方で、耐暑性系統は蒸散が活発で同位体比の値が低い傾向にある。この性質を利用して系統選抜を行なった。

1,2 の結果から灌漑区においても収量を落とさず、かつ同位体比分析において節水性形質を保持する系統を節水型耐乾性候補系統として選抜し、蒸散活性がコントロール区で極めて高い耐暑性系統との交配により組換え自殖系統の作製を行った。

Ryosuke Mega (Specially-Appointed Assist. Prof., Plant Physiology and Molecular Biology)

Arid area is known to occupy approximate 40% of land in the world. Improvement of drought stress in plant enables many arid areas due to little rain fall to convert arable in the world. Enhancement of plant drought tolerance can greatly contribute to solve the food problem that is becoming worldwide serious.

Abscisic acid (ABA) is closely involved in drought tolerance. ABA receptor overexpression improves ABA hypersensitivity to enhance drought stress tolerance of plant. Since ABA receptor exist universally in plant, utilization and application of ABA receptor can contribute to generate drought tolerant crop. So far, we characterized wheat ABA receptors (TaPYLs) and generated TaPYL overexpressing wheat (TaPYLox). As a result, TaPYLox was validated to possess “water-saving drought tolerance”. Then, the difference of carbon isotope discrimination indicated in water-saving drought tolerant wheat were used to screen out water-saving and heat-tolerant wheat genotypes in this fiscal year. This and the other agronomical traits data were collected in the field trial in Sudan agricultural research corporation.

The followings are highlights in this fiscal year.

1. One hundred sixty of multiple synthetic wheat derivatives were cultivated in the field with water supply controlled by using irrigation system to evaluate drought tolerance.
2. The differences of carbon isotope discrimination between water-saving and heat-tolerant genotypes were evaluated by IR-MS to screen out them. The higher ^{13}C composition was in water-saving one while the lower ^{13}C composition was in heat-tolerant. The values are dependent on their life-span transpiration activities.

The water-saving genotypes sustaining yield even under drought condition and the heat-tolerant genotypes with extremely high transpiration activity were selected based on these data. In addition, these candidates were crossed each other to obtain recombinant inbred lines.

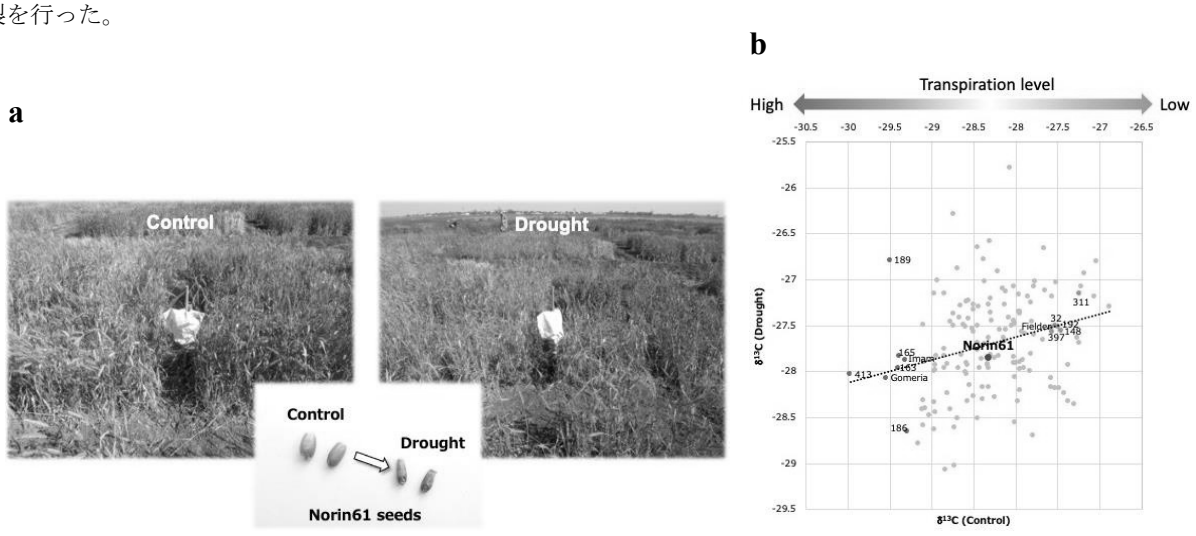


Fig. (a) Photos of the fields under control and drought conditions. Norin61 seeds as a check cultivar shrank by drought stress. (b) Correlation between ^{13}C composition values under control (x-axis) and drought (y-axis) condition.

(3) 外国人研究員/ Foreign Research Scholars

Mubarak Abdelrahman Abdalla Ali (Visiting Prof., Land Degradation and Restoration)

April 2019 - September 2019
Towards sand stabilization by enhancing resilience using different composts

Degradation by wind erosion is detrimental to both soil and land quality in arid regions. This study was conducted to investigate the effectiveness of surface application (1 and 3 cm height) of aerobically incubated (24 weeks at 75% water holding capacity) compost from chicken (CM), farm yard manure (FYM) and rice husk (RH) and a control (no treatment) on properties of a sandy soil and sand particles stabilization. We determined the mass loss of compost and changes in the surface structure of the soil using scanning electron microscope (SEM). Soil hardness, pH, organic carbon (OC), total nitrogen (TN), micriobially induced $CaCO_3$, water holding capacity, and dry aggregate stability, were also determined. Mass loss from chicken manure (CM) composts with both application depth was 2.1_2.5 fold that from FYM. OC and TN released from the RH compost were the lowest. Total soil N, OC, and pH in the CM and FYM treatments were higher than that in the RH treatment. Soil hardness in the CM compost was 6.7, 1.4, and 2.7 times the mean determined in the control, FYM and RH, respectively, whereas $CaCO_3$ (Fig. 1) in CM treatment was 56 and 69% higher the percentage found in the FYM and RH, respectively. Soil hardness was in the order of CM3cm > CM1cm > FYM1cm > FYM3cm > RH1cm > RH3cm > C. Erodible fraction (0.85_1.0 mm) decreased linearly (Fig. 2) with increase in soil hardness (R2 > 0.9), OC, $CaCO_3$ and dry aggregate stability (R2 > 0.5). Application of the compost from FYM and CM decreased erodible fractions up to 5 and 15%, respectively. From the percent apparent effects of compost on aggregation and erodible fractions, it can be concluded that surface application of CM compost is an effective means of stabilizing sand particles.

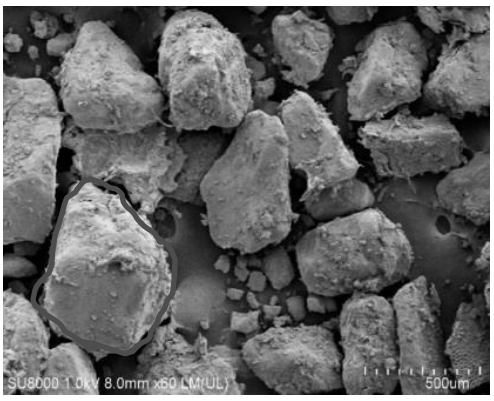


Fig.1. Scanning electron microscope images (500 μm) heavy deposition of microbially induced $CaCO_3$ in CM after 16 weeks of incubation

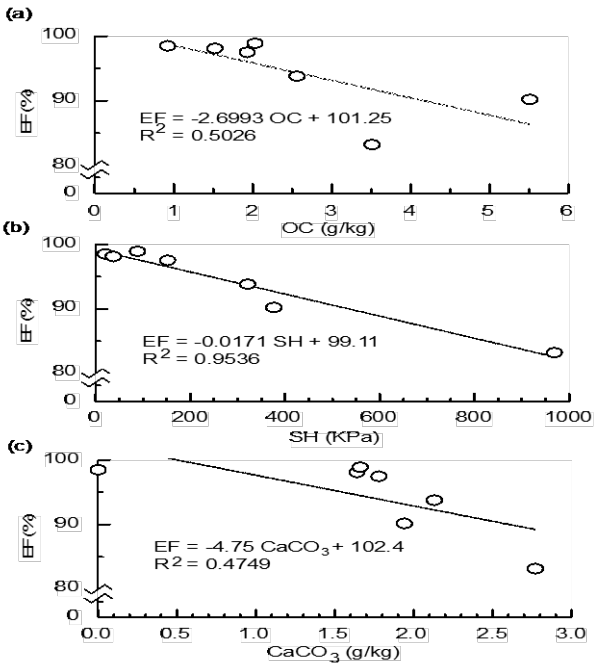


Fig.2. Relations between EF and OC (a), SH (b) and, CaCO3 (c) of the top 2 cm depth in the control, FYM 1cm, FYM 3cm, CM 1cm, CM 3cm, RH 1cm and RH 3cm

Amrakh Mamedov (Visiting Prof., Soil & Water Management and Conservation)

April 2019 - March 2020

- Water use of plant as affected by abiotic stresses.
- Physical quality of soils: effect of land use (crop, grass, bush, forest), soil types, amendments application (manure, compost, lime, gypsum, biochar, PAM) and microbe inoculation

Eggplant water use under abiotic stresses: pot experiment. The tolerances of eggplant to drought and salinity stresses was evaluated using set of pots with growing eggplant and equipped with moisture and salinity sensors. Parameters of macroscopic root water uptake model were determined. Plant water uptake at each depth and time was calculated by including water matric and salinity osmotic potentials into the stress response function, and eggplant response to abiotic stress was predicted accurately.

Land use and PAM application effects on structure stability. ● Contribution of land use (crop, grass, bush and forest) and soil conditioner - amendments (polyacrylamide, PAM) on physical quality of soils (e.g. structure stability, and water retention parameters) from 3 Ethiopian watersheds (Guder, Abagerima and Dibatie) were evaluated. ● Approach aided in assessing land use and alternative and combined soil conservation efficacy. ● Soil physical quality (aggregate- structure stability and water retention) increased with increase in soil organic carbon (SOC=1-8%: forest > grass > bush > crop) and PAM application (25 and 200 mg l^{-1}), but the effect was soil and land use dependent. ● PAM adding to long-term tilled cropland improved its stability over soils from grass- and bush land and eased the difference between the samples from different land use (Fig. 1).

Aggregate-structure stability as affected by land use and inoculation by microbes. ● This study was aimed to evaluate the inoculum potential of Ethiopian forest soil and its effects on native tree (Olea and Albizia) seedling growth performance, and crop land and 3 forest land soil physical quality. ● Soil structure stability was significantly higher (i) for forest soils than degraded cropland soil, which was associated with loss of organic matter and useful microbes, and (ii) in bacteria and fungi inoculated soils than in sterilized soil for most of treatments.

Structure stability of soil treated with three amendment under consecutive rain storms. ● Contribution of (i) surface applied 6 dry PAM rates (0, 20, 40, 60 kg/ha), and (ii) combination of amendments: PAM 40 kg/ha + gypsum 4 t/ha or lime 2t/ha was studied ● Structure stability increased with increase in PAM rate. After 6 rainfall storms (400 mm rain), stability of PAM 40-60 kg/ha or PAM 40 kg/ha + lime 2 t/ha treatments was significantly higher than control and substantially reduced runoff and soil loss.

Quality of field cultivated soil treated with amendment. ● The role of soil amendments (e.g. PAM, lime, gypsum, biochar, manure) on soil quality and structure stability, and water retention parameters of 3 long-term intensively cultivated soils from 3 Ethiopian watersheds (Dibatie, Guder, Aba Gerima) was evaluated to assess soil conservation practices efficacy. ● PAM combined treatments was very effective in sustaining soil quality by reducing runoff and erosion.

Sandy soil stabilization by composts. ● Effectiveness of surface application (1 and 3 cm) of aerobically 24 weeks incubated compost from chicken, farm yard manure and rice husk and a control on dry aggregate size distribution was studied and properties of a sandy soil and sand particles stabilization. ● Erodible fraction (>0.84 mm) of sandy soil decreased linearly with increase in soil organic carbon, and $CaCO_3$ and dry aggregate stability. ● Composts decreased erodible fractions up to 5- 15%, respectively, revealing that it is an effective means of stabilizing sand particles.

Water retention and structure stability of typical Ethiopian and Japanese acidic soils. ● Contribution of lime and PAM wetting with deionized water and ethanol on near saturation water retention and structure stability of 5 Japanese soils and 6 Ethiopia soils were investigated. Soils showed huge variation in resistance to slaking by wetting. ● Effect were strongly related to soil chemistry (e.g. clay mineralogy, pH, SOC) and land use history and elevation.

Other activities.

- Published 4 papers and submitted 6 papers for publication.
- Preparing 4 papers for submission.
- Contribution to SATREPS project on soil conservation.
- Field survey trips to Ethiopia and laboratory experiments.
- Training and supervising PhD students at ALRC, Tottori University and Bahir Dar University, Ethiopia.
- Given seminar at ALRC, Tottori University.
- Presentation at two international conference and submitting abstract to international conference.
- Scientific committee member of international congress.
- Participating in seminars and other relevant ALRC and IPDRE meetings.
- Reviewed several papers for Web of Sciences journals.

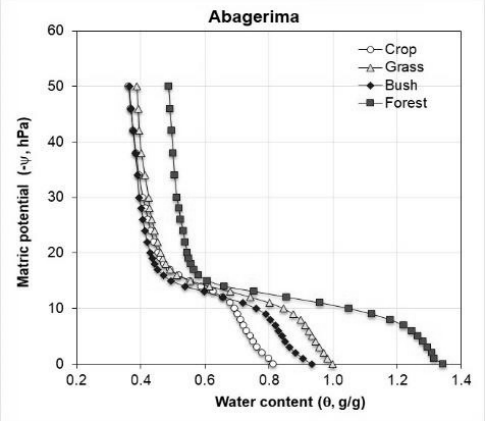


Fig.1 Soil water retention as affected by land use

Jian Sun (Visiting Assoc. Prof., Climate Change Adaptation)

April 2019 - March 2020
Protecting alpine grassland need to double check the effectiveness of grazing exclusion with fences in Tibetan Plateau, China

1. Has grazing exclusion improved grassland growth and soil fertility?

2. Fencing increases grazing pressure in unfenced areas

3. Fencing limits wildlife activity

4. Fencing reduces herders' satisfaction with the current grassland management policy

5. Fencing increases government financial burden and conservation expenses

By synthesizing the results of published studies on fencing experiments in the past few decades on the TP, we found that fencing promoted vegetation growth, but only in the aboveground parts and only in the first few years after the installation of fences. However, the effects of fencing on ecosystem processes and functions were slightly different in the alpine meadows and steppes. Short-term fencing enhanced plant diversity but not BGB and soil fertility metrics (SOC, STN, and STP) in the alpine meadows. Short- and medium-term fencing in the alpine steppes increase not only the AGB, but vegetation coverage as well. Interestingly, we also found that long-term fencing (present for more than eight years) had little effect on vegetation growth and soil fertility. Our results confirmed that fencing hindered wildlife movement and increased grazing pressure in unfenced areas, exacerbating the overgrazing issue in the north of Tibet.

Most importantly, although the Chinese government has implemented many policies over the past 20 years to protect grasslands there is a need to modify the core structure for policy making and ongoing management (Fig. 1). The grassland management policy for the TP was devised at national and local levels but lacked third-party evaluation. Reviews of the policy have been carried out, as in the current study, but without inbuilt mechanisms to implement findings. Reviews and policy adjustments need to be better aligned. Coordinating committees for policy review and management should include independent evaluators and herders as well as government officials, all charged with delivering clear environmental and livelihood benefits.

Given the complexity of the effects of fencing on ecosystem processes, livestock carrying capacity, wildlife habitat, and herders' livelihoods and culture, we do not consider the existing studies on the topic to be conclusive and suggest that further studies, especially long-term field research, are urgently needed. Nevertheless, according to our results, we propose the following methods for improving current grassland management policies on the TP: (1) traditional free grazing is encouraged to maintain or resume the traditional grazing practices and culture if the grasslands have not been degraded; (2) in case fencing is necessary, such as in a severely overgrazed area, short-term fencing of four–eight years is preferable, with removable fences that can be reused elsewhere afterwards; (3) high fence density and connectivity should be avoided, and the existing long-term fences should be removed for the benefits of wildlife; and (4) regular and comprehensive assessments are needed to ensure the policy is being effectively managed to deliver benefits in a timely fashion.

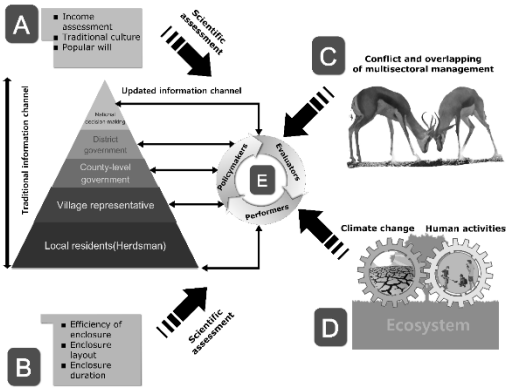


Figure 1 Scientific grassland management workflows that establish circulatory and long-term mechanisms and comprehensively consider the viewpoints of performers, evaluators, and policymakers. Elements based on local residents (income, traditional culture, and public will, A), fencing projects (efficiency, layout, and duration of fences, B), government policies (conflict and overlapping of multisectoral management, C), and global changes and human activities (D) involved in grassland management workflows are incorporated into a comprehensive analysis to promote harmonious and sustainable development between humans and nature (E).

Faisal Elhag (Visiting Prof., Range-Livestock and Climate Change)

November 2019-March 2020
Forecasting Climate Change - Rangelands - Livestock Interactions for Possible Adaptation under Dryland Farming in Sudan

Local ecosystems provide the main source of livelihoods for many of the world's poor. The productivity of this livelihood base is highly vulnerable to climate-related stresses. Serious environmental constraints, likely to worsen due to climate change, persistent water scarcity, rapid population growth, frequent droughts, high climatic variability, land degradation and desertification, and widespread poverty. Extreme climate events, like droughts, have led to loss of assets and compelled may pastoral communities to shift to traditional cultivation of crops or to seek jobs in nearby towns. Only few models assess the effects of changing climatic conditions on pastures and livestock dynamics and aim at a generic understanding of rangeland systems. There is a high need for proper understanding of livestock-range-climate interactions for strategic planning. Therefore, our objectives were to simulate perennial vegetation dynamics under different rainfall regimes, vegetation condition and temperatures across different ecological zones in order to enable forecasting to build resilience of pastoral and agro-pastoral communities under dryland conditions in the Sudan and similar ecological areas, and identify challenges and opportunities for adaptation to expected climate change.
Data sets collected included climatic data (rainfall, maximum and minimum temperature, relative humidity), rangelands attributes (areas, biomass productivity, species composition), livestock population statistics (populations, agroecological distribution, livestock classes) for eight States in Sudan. These data sets were categorized according to ecological zones, adjusted, and statistically analyzed. Correlations analyses were done to establish relations among climatic variables, rangelands attributes and livestock classes distribution across different ecological zones. Then, simple, and multiple regression analyses were undertaken for trends in rangeland productivity in relation to climatic variables. NDVI values derived from MODIS images were compared to ground measurements by standard regression procedures. A sub-section of one pixel (250*250m) was selected from MODIS image. Each sub-section covering one of the ground measurements plots. Woody and herbaceous biomass measured from ground truth sites and NDVI values were used to develop equations for estimating biomass production for all pixels. Regressing NDVI values for each corresponding ground truth site value produced the linear model relating biomass values measured during the fieldwork in 2000-2017 with the NDVI value taken at the same time. Standard least squares linear regression (for normal and $\log_{10}$ transformed data) was employed and an inverse prediction was used to convert NDVI values to biomass values (gm/m^2) at the time of maximum biomass production (7-14 September) in rangelands across eight States covering three agroecological zones. To estimate carrying capacities and stocking rates, a daily dry matter disappearance rate of 7.5 kg/ha was attributed to one tropical livestock unit (TLU) per day. Carrying capacity was expressed as number of hectares needed to support one TLU for one year (ha/TLU/year), considering that dry matter disappearance of herbaceous biomass without grazing at about 4% a month in the Sahel, i.e. 36% for nine month. Stocking rate was expressed as the actual number of animals on a management unit throughout the time period of grazing. Some of the results revealed clear different trends of stocking rates for different agroecological zones (Figure below). There was also a clear significant association between biomass production (ton/ha) and NDVI (Table below). Carrying capacity ranges between 1.6 ha/TLU/year in the semiarid zone, which was the best, to more than 46 ha/TLU/year in the semidesert. Most livestock population being concentrated in the arid and semiarid agroecological zones, with the semidesert zone hosting only 1-3% of total livestock population in the region. Grasses contribution to biomass production ranged between 41% in semiarid zone to 96% in the semidesert zone. Browse contribution to biomass production ranged between 2% in semiarid zone to 14% in arid zone. Crop residues contribution to biomass production ranged between 0% in semidesert zone to 52% in semiarid zone. Further, some adaptation options for improving livestock productivity (particularly small ruminants) under dryland farming conditions were proposed.

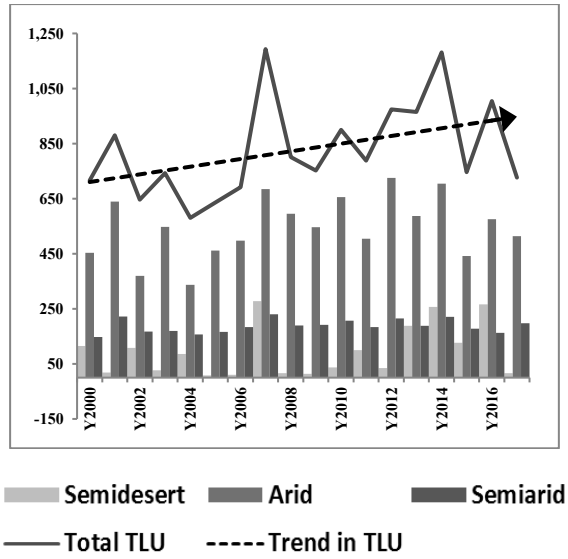


Fig. 1. Trend in distribution of livestock in agroecological zones

Table 1. Regression equations relating herbaceous, foliage and total biomass production with vegetation indices (VI)

VI	Regression equation	R^2	N
Herbaceous biomass (HB)			
NDVI	HB = - 128 + 759 NDVI	0.82*	48
Log (NDVI)	Log (HB) = 3.06 + 2.18 Log (NDVI)	0.81*	48
Foliage biomass (FB)			
NDVI	FB = - 153 + 689 NDVI	0.62*	34
Log (NDVI)	Log (FB) = 2.96 + 2.59 Log (NDVI)	0.50*	34
Total (herbaceous + foliage) biomass (TB)			
NDVI	TB = - 312 + 1490 NDVI	0.86*	34
Log (NDVI)	Log (TB) = 3.32 + 2.36 Log (NDVI)	0.82*	34

* Significant at 0.01 level

Ammar Wahbi (Visiting Prof. soil-plant water relation)

November 2019 – March 2020

Drought tolerance in wheat varieties using carbon isotope discrimination

The most challenge in wheat improvement programs in Mediterranean environment is to improve drought tolerance, yield stability and the efficiency of water use. Several breeding methods and selection approaches were used, but, all required long term studies. Therefore, the main aim of our article investigated during November 2019 to April 2020 at ALRC, Tottori University was to highlight the use of Carbon Isotope Discrimination (CID, $\Delta^{13}C$; $^{13}C/^{12}C$ isotope ratio or Δ) as a possible tool for breeding drought tolerance genotypes. However, CID could be used as indicator for high transpiration efficiency. Farquhar et al. (1982) found a positive relation between CID and water use efficiency. So, it is possible to use CID as an index of transpiration efficiency since CID and transpiration efficiency are positively related. CID and yield were positively related in many studies in Mediterranean environments. In this article, we show this relation and also evaluate surrogates for CID which is cheap and reliable. Two stable isotopes of carbon occur naturally, the more abundant ^{12}C (98.9 atom %), and the less abundant ^{13}C (1.1 atom %). During photosynthesis (the assimilation of atmospheric CO2 into plant tissue), physico-biochemical processes discriminate against the heavier ^{13}C isotope in favour of the lighter ^{12}C species, which forms the basis of the $\Delta^{13}C$ technique. Thus CID provides a time integrated index of photosynthetic activity and is related to transpiration efficiency. However, this technique is differed between C3 and C4 plants (Figure 1).

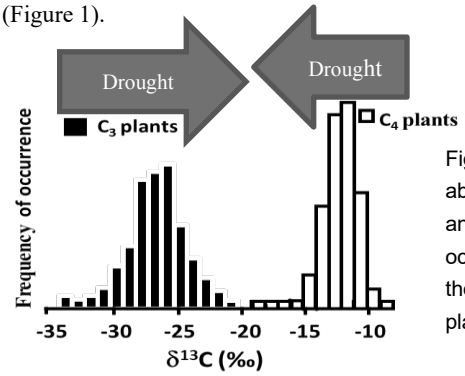


Fig.1 Natural abundance of ^{13}C and frequency of occurrence for the C3 and C4 plants

Several experiments between 2004 and 2007 were conducted in the field in Syria (four sites varied in rainfall with more emphasis about the dry locations; Tel Hadya and Breda) using six durum wheat genotypes varying in CID but similar in phenology. Post anthesis drought is frequently happened with high air temperature (May-June) (Wahbi and Shaaban, 2011). Measurements were carried out throughout the season in the plants as well as in the soil water. The 4 fully expanded leaf was sampled as well as the grain to determine the Δ (big delta) natural abundance ($\delta^{13}C$; small delta) at the International Atomic Energy Agency (IAEA) laboratories, Seibersdorf, Austria.

$$\delta^{13}C\ (‰) = [(Rsample/Rreference) - 1] \times 1000 \quad (1)$$

where R, the isotope ratio = $^{13}C/^{12}C$, measured with a precise isotope ratio mass spectrometer. The primary reference standard for $\delta^{13}C$ measurements is fossil carbonate (Pee Dee Belemnite), where RPDB x 10^6 = 11237.2 ± 9.0. Since, this value was established as $\delta^{13}C$ value of zero. So, use of this standard gives most natural material a negative $\delta^{13}C$ signal (Figure 1).

The use of small delta $\delta^{13}C$ is confusing for work with plants, since the discrimination values $\Delta\ ^{13}C$ are usually positive while those of $\delta^{13}C$ (measured or absolute values) are usually negative (Figure 1).

The δ units are not the same as molarity or Atom % notation, but are ratios. The δ units must be used only for comparison.

$$\Delta\ ^{13}C\ (\text{per mil or ‰}) = [(\delta^{13}C\ air - \delta^{13}C\ plant)/(1 + \delta^{13}C\ plant)] \times 1000 \quad (2)$$

where $\delta^{13}C$ air value of atmospheric CO2 is (–8‰) and $\delta^{13}C$ plant is the measured values of the plant. ($\Delta\ ^{13}C$ are 27.9, 22.1, 17.4 and 12.2 corresponded to $\delta^{13}C$ of -35, -30, -25, and-20 respectively; Figure 1)

The results showed the CID of 4-fully expanded leaf is higher than that of grain. This is due to the fact, that drought started at post anthesis and is affecting the grain. However, comparing the CID of the wheat with that of the legumes genotypes (average of 18 genotypes where CID ranged between 16.27 and 20.23) showed high ability to transpire despite the severe drought in the desert of Syria (Figure 2).

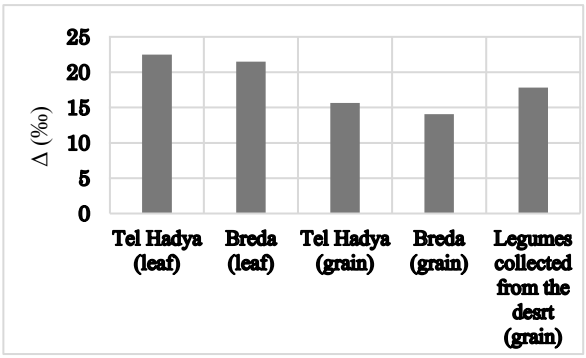


Fig. 2 Carbon isotope discrimination (Δ) for the 6 durum wheat genotypes grown at two locations in Syria (Tel Hadya and Breda) as well as legumes grain collected from the desert in Syria

We conclude, that to minimize confusion, we used $\Delta\ ^{13}C$ (big Δ, positive values) rather than $\delta\ ^{13}C$ (small delta, negative values), and cheaper alternative ash content trait.

Other activities:

- Paper accepted in Special issue in Frontiers and water
- Participating in two national conferences (delivering one oral presentation)
- Giving top scientist lectures (three) as well as lecture to the section and assisting students in research proposals and statistical analysis
- Submitting three abstracts (accepted) to international conference
- Working on establishing scientific links and research proposals with national and international institutes

(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を作ることを目指している。このため、第1期の研究活動を発展させてより広範な遺伝資源を高度に利活用するために乾燥地植物資源の収集と評価を進めている。

本年度は、以下の研究を進めた。

- ジャトロファの耐寒性系統を作るため、系統を選抜した。
- ジャトロファの系統別に開花時期を調査した。
- ホホバの環境耐性を評価するために増殖した。
- 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。

Female flowers of *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 2019, we promoted the following research.

- I selected *Jatropha* plants in order to make the cold-tolerant variety.
- I investigated the flowering season for each *jatropha* variety.
- I propagated jojoba in order to evaluate it.
- I 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.

Various varieties of jojoba

伊藤　健彦（動物生態学）

乾燥地では長距離を移動する野生動物の移動生態学と保全学を、国内では野生哺乳類の調査手法開発などを進めている。

本年度に実施した外部資金による研究には以下のものがある。

（1）草原棲哺乳類の異なる移動戦略共存機構の解明と移動誘発ホルモン検出の試み（科学研究費補助金 挑戦的研究（萌芽）、研究代表者）

（2）「遊動」を予測する：モンゴル草原の環境条件と野生草食獣の移動・活動量の関係（科学研究費補助金 新学術領域（公募研究）、研究代表者）

（3）小型無人航空機による大型哺乳類の検出精度の推定と個体数モニタリング手法の確立（公益信託エスペック地球環境研究・技術基金、研究代表者）

（4）金華山島におけるシカ個体数の長期継続調査に向けたドローン利用手法の確立（自然保護助成基金プロ・ナトゥーラ・ファンド助成、研究代表者）

本年度は特に以下の成果を得た。

1．モンゴルの草原地帯に生息する野生草食獣モウコガゼルの長距離移動への、ストレスホルモン濃度が影響する可能性の検出に挑戦している。リアルタイム衛星追跡により、遊動的な動物の位置を特定し、定期的な糞採集と、モンゴルでのホルモン分析体制を確立した。

2．新学術領域「生物移動情報学」がめざす、動物のナビゲーション能力解明のため、モンゴル南部のゴビステップ地域でモウコガゼルの 3 軸加速度計付 GPS 首輪による追跡を開始した。過去に追跡した個体のデータ解析から、モウコガゼルの数時間単位の活動周期の存在とその季節変化を明らかにした。

3．モンゴルの草原に生息する野生草食獣 4 種の種間比較を実施した。より乾燥した地域の種・個体ほど、夏期の移動範囲が水場付近に制限されることを示唆した。

4．ドローン搭載熱赤外カメラによる大型哺乳類調査の調査手法開発を進めている。鳥取だけでなく宮城県や北海道でも調査を実施し、落葉樹林が優占する 10km^2 の島全体の、ドローンによるニホンジカの個体数調査を可能にした。

Takehiko Ito (Project Researcher, Animal Ecology)

I conduct movement ecology and conservation of wildlife in drylands and methodology developments for wild mammal research in Japan.

External funds for research in this fiscal year are as follows:

(1) Coexistence mechanism analysis of different migration strategies of grassland mammals and detection of hormones inducing migration. (Grants-in-Aid for Challenging Research (Exploratory), Principal Investigator)

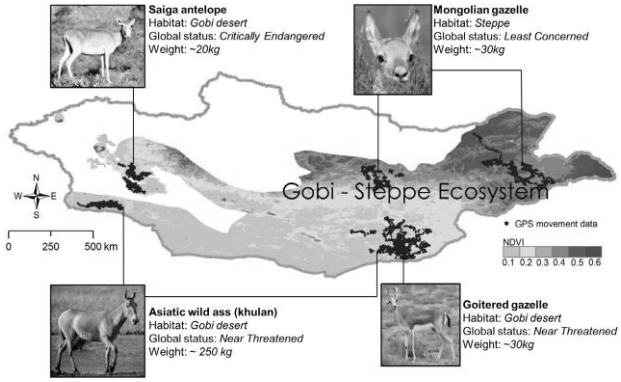
(2) Prediction of nomadic movement: relationships between movement and activity of wild mammalian herbivores and environmental conditions in Mongolia's grassland. (Grants-in-Aid for Scientific Research on Innovative Areas (Publicly Offered Research), Principal Investigator)

(3) Estimation of detection accuracy of large mammals using unmanned aerial vehicles and establishment of monitoring methodology of population numbers (ESPEC Foundation for Global Environment Research and Technology, Principal Investigator)

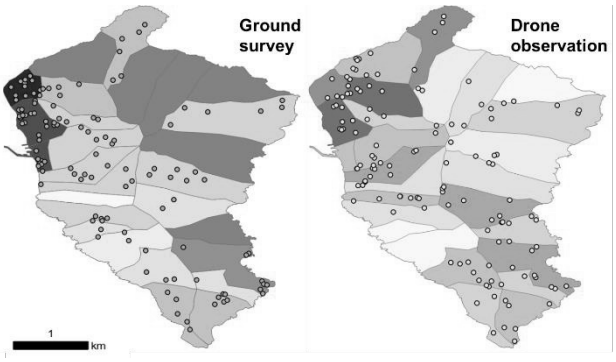
(4) Methodology establishment using drones for long-term monitoring of sika deer population on Kinkazan Island. (Pro Natura Fund, Principal Investigator)

In this fiscal year, I obtained following results:

1. To examine the possibility of stress hormone effects on long-distance movements of Mongolian gazelles inhabiting Mongolia's grassland. We established a hormone analysis system in Ulaanbaatar with gazelles' fecal sample collection in regular intervals using real-time satellite tracking.
2. The innovative area, "System Science of Bio-Navigation", aimed to understand animal navigation. We started satellite tracking with 3-axis accelerometer of Mongolian gazelles in south Mongolia. We revealed activity cycle of several hours and its seasonal change.
3. A comparative study of 4 wild mammalian herbivore species in Mongolia's grassland was conducted. Stronger constraint of water points for movement patterns during summer for animals in dryer regions was suggested.
4. For methodology development using drone-mounted thermal-infrared cameras for research on large mammals, we conducted field surveys in Miyagi Prefecture and Hokkaido, Japan. Our method enabled drone census of sika deer on an island of 10 km^2 dominated by deciduous forests.



Four mammal species of the comparative study in Mongolia (from Nandintsetseg et al. 2019).



Sika deer distribution detected by the ground survey and the drone observation on an island.

Jiaqi Liu (Project Researcher, Environmental Physics)

The Environmental Physics Subdivision conducts research mainly as follows:

(1) Experimental analysis of inhibitory effect of coverage and porosity of plants on wind-blown sand by using artificial plant models.

(2) The structural characteristics of blown sand flux over a fine gravel surface by wind tunnel experiment.

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

1. Wind erosion is one of the main hazards of dust storms in Mongolia. To prevent or reduce wind erosion, it is important to understand the interaction between wind and near-surface structures. Plants can reduce wind speed, and they can prevent soil surface erosion. Because the plant has many characteristics, such as geometric shape, porosity, flexibility etc. It is very difficult to study effects of those characteristics on wind erosion at the same time. I intend to investigate effect of each individual characteristic of plant and here I mainly focus on porosity.

   To use the wind tunnel for wind-blown sand experiments, vegetation needed to be modeled physically by an array of roughness elements corresponding to simple conceptual models of vegetation structures. The results of our previous research indicate that plants with inverted truncated cone shapes are more suitable for preventing wind erosion. Therefore, in order to understand the inhibitory effect of porosity on wind erosion, I decided to model an inverted truncated cone shaped plant. The diameter of the top and bottom bases of the inverted truncated cone is 68.68 mm and 36.78 mm, respectively. The height is 71.23 mm. I used inverted trapezoidal aluminum plates of different size (thickness of 2.05 mm) to simulate the “stalks” of plants, and evenly inserted on a circular base with a thickness of 5 mm. As shown in the figure, the accuracy of the model is increased in the following ways.

   - Groove structure on the base is designed to ensure each board can be closely near the base surface.
   - The distance between the lower part of each board is set to 0.1 mm in order to easily assemble and disassemble the board.
   - Height of each board is designed based on the fixing board at the center to obtain a flat top surface of the model.

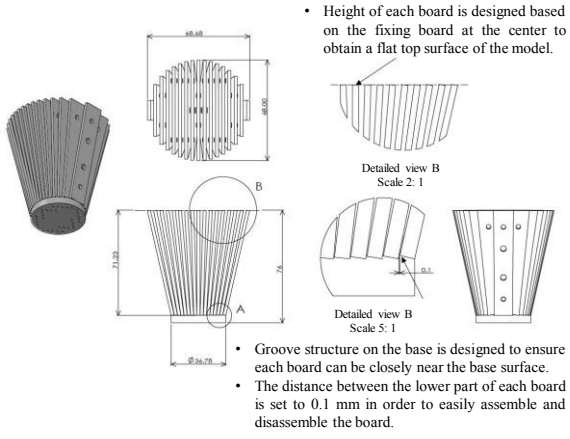


Fig. 1 Structure of porous roughness elements

By changing the number of aluminum boards, it is feasible to obtain four porosity of 8.8%, 14.7%, 26.5%, 50%. By changing the number of models, it is feasible to obtain different coverage. Therefore, the inhibitory effect of the porosity of not only individual plant but also the rough element array on the flying sand can be discussed.

2. To make effective prevention measures against dust problems, it is indispensable to understand structural characteristics of wind-blown sand. The structure of wind-blown sand represents variations with height of blown sand flux carried by airflow and determines the intensity of sand transport. Meanwhile, it reflects the saturate status of wind-blown sand as well as its effect on surface erosion. So far, little is known about the effects of fine grain gravel and its coverage on the structure of wind-blow sand.

   I investigated effects of fine grain gravel coverage on variations of blown sand flux with height in a compact wind tunnel equipped with a turbulence generator and a piezoelectric blown sand meter. To do so, I compared structural characteristics of wind-blown sand on a flat sand surface and gravel surfaces with different coverages. Differed from the exponential distribution with height on flat sand surface, structure of wind-blown sand over gravel surface with coverages of 20% or greater showed a non-monotonical distribution. At gravel coverages from 20% to 30%, due to collisions between sand particles and gravel surface, a zone of peak blown sand flux appeared within 6-10cm height above the surface. The height of peak was observed at all experimental wind speeds. To analyze erosion status of wind-blown sand, I evaluated a structural characteristic index (λ). Values of λ over gravel surfaces were greater than 1 at any wind speed, indicating an unsaturated and erodible status. Moreover, I found that the blown sand flux at 4 cm height accounted for about 20% to the total flux, and the proportion was independent of wind speed and gravel coverage. This finding is conducive to simplify estimation of the total blown sand flux in the near-ground surface through filed observation.

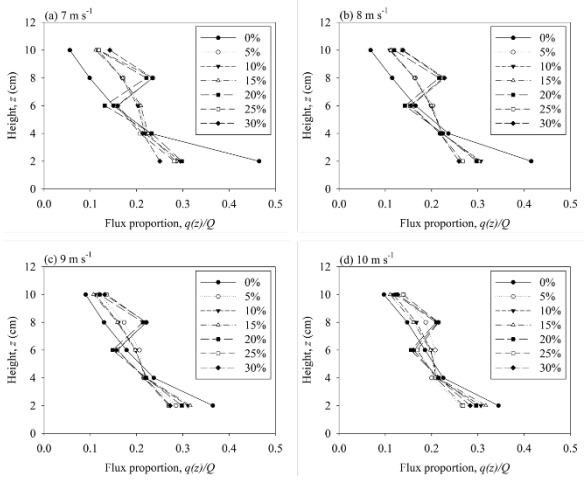


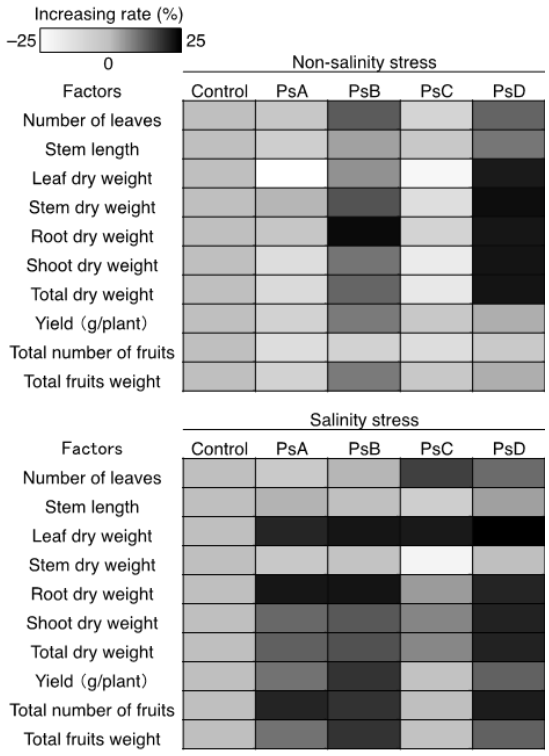
Fig. 2 Vertical profiles of the relative blown sand flux under different wind speeds at flat sand surface and six different gravel coverage.

中原　浩貴（植物生産学）

病害や虫害などの生物的ストレス、塩害や乾燥などの非生物的ストレスは作物の生産性を低下させる要因である。また、それらの対策（例えば、化学農薬・化学肥料の過度な使用や、大規模な灌漑やリーチングなどの水資源の利用）による環境負荷も問題となっている。そのため、将来の安定的な作物生産を実現するためには、環境保全型の作物生産技術の確立が重要である。

本分野では、主に病害と塩害に対して複合的かつ環境保全学的な対策技術を開発するために、非病原性細菌を利用した植物の病害抵抗性と耐塩性の向上に関する研究を実施している。また、共同研究として、カルシウム資材を利用した植物の耐塩性の向上（熊本県立大学、鳥取大学との共同研究）、鉄化合物を利用した土壌病害防除技術の開発（熊本県立大学、滋賀大学、鳥取大学との共同研究）に関する研究を実施している。

非病原性細菌を利用した植物の病害抵抗性と耐塩性の向上に関する研究について、令和元年度は主に以下の研究成果を得た。トマト栽培圃場から分離した *Pseudomonas* 属細菌の中から、植物の耐塩性を向上させる菌株を探索するため、一次スクリーニングとして細菌の植物成長促進因子（リン酸塩溶解能、シデロフォア、インドール酢酸、ACC デアミナーゼ産生能など）の生産能の高い菌株を選抜した。二次スクリーニングとして、選抜菌株を接種したトマトを非塩ストレス条件と塩ストレス（NaCl）条件下で栽培し、根・茎・葉のバイオマス量と果実収量を調査した。結果として、非塩ストレスと塩ストレス栽培条件において、植物成長促進効果を示す数菌株が得られた。



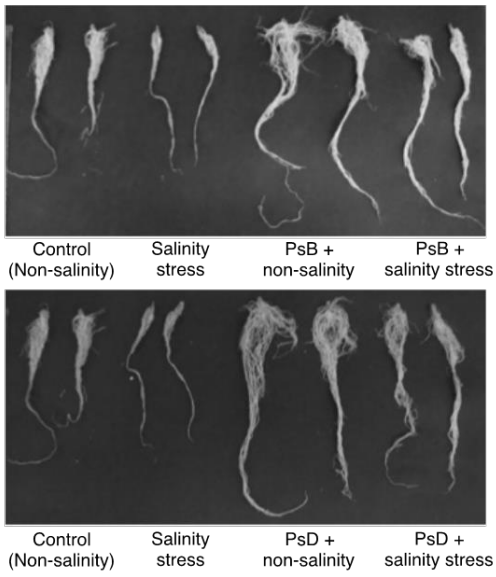
Increasing rate of biomass and yield in the bacterial inoculated tomatoes under non-salinity and salinity conditions.

Hiroki Nakahara (Project Researcher, Plant production science)

The biotic stress such as plant diseases and pest damage, and abiotic stress such as salt damage and drought are factors that reduce the productivity of crops. The environmental impacts by measures against their stresses are also a problem (e.g. excessive use agricultural chemicals and chemical fertilizer, and use of water resource such as large-scale irrigation and leaching). Therefore, it will be important to develop the technology of environmental conservation type for stably produce crops in the future.

This subdivision conducts research on the improvement of disease resistance and salinity tolerance in plants by using non-pathogenic bacteria, mainly in order to develop technology for multiple and environmental conservation measures against plant diseases and salt damage. As a joint research, we conduct research on improvement of salinity tolerance in plants using calcium fertilizers (Joint research of Prefectural University of Kumamoto and Tottori University) and development of soil-borne disease control technology using iron compounds (Joint research of Prefectural university of Kumamoto, Shiga University and Tottori University).

In the research on the improvement of disease resistance and salinity tolerance by using non-pathogenic bacteria, the following research results were obtained in this fiscal year. In order to select for bacterial strains that improve salinity tolerance in plants, *Pseudomonas* strains were isolated from the tomato fields, and the bacterial strains were selected based on productivities of plant-growth-promoting factors (e.g. phosphate solubilization, productivities of siderophore, indole acetic acid and ACC deaminase) as primary screening. The bacterial inoculated tomatoes were cultivated under non-salinity and salinity (NaCl) conditions, and then biomass of roots, stems and leaves and yield of fruits were measured as second screening. As the result, several strains were obtained that promote plant growth in tomatoes cultivation under non-salinity and salinity conditions.



Effect on growth of roots in the bacterial inoculated tomatoes under non-salinity and salinity conditions.

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）　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

（2）　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

（3）　オミックスを利用したコムギにおけるストレス耐性メカニズムの解明

（4）　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

これらの研究は、限界地プロジェクトの援助によって、主としてスーダン・日本で行われている。

本年度は、特に以下の研究で成果を得た。

1．スーダン実験圃場においてコムギ系統のリン欠乏耐性選抜試験結果 2 年間分の収量を含めたデータを基に、R1 年度では遺伝的データとの相関性を計算する GWAS 解析を用いて解析し、野生遺伝子由来のリン欠乏耐性に関係するマーカーを検出した。（Figure 1）

2．鳥取大学乾燥地研究センター内の人工気象器内において、耐性系統をリン欠乏土壌環境で栽培した結果、収量を安定させる特徴的な要因（根、光合成、栄養元素など）を得た （Figure 2）。またこれらの耐性系統の共通した形質をマーカーとして選抜できる可能性を現在試験中である。

3．圃場試験の結果を解析したところ、特定の系統由来のコムギ集団にキャノピー温度と収量の相関関係があった。この集団は特定の植物ホルモンの感受性に関しても相関があると類推される報告があることから、今後のホルモン感受性との相関研究が期待されている。

4．耐暑性系統を有する特定のコムギ系統の高速液体クロマトグラフ質量分析システム（LC-MS）を用いたメタボローム解析、同位体比質量分析システム（IR-MS）を用いた安定同位体比を測定し、耐暑性メカニズムの解析等の実験系を行なっている。また耐乾性のメカニズム解明のため、耐暑性同様に実験系を行なっている。

Yuji Yamasaki (Project Researcher, Molecular Breeding)

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

(1) Evaluation and selection of tolerant wheat lines under abiotic stresses especially dehydration and heat stress as main stresses of arid-land area

(2) Selection and characterization of tolerant line in wheat under phosphorus deficiency soil conditions

(3) Characterizing and clarification of these stress tolerant mechanisms using omics technology

(4) Study on correlation between canopy temperature and yield of field growth

These studies are conducting under Marginal region Project especially in Sudan and Japan.

The following things are my projects in the fiscal year 2019 as my third contract year.

1. Based on the screening data under the phosphorus deficiency conditions in Sudan in the two consecutive seasons, Genome Wide Association Study (GWAS) described the location of phosphorus deficiency tolerant genes derived from wild genes (Figure 1).
2. In the growth chamber experiment in ALRC, Japan, the tolerant lines show interesting features relating grain yield such as root morphology, photosynthesis and ionome in response to phosphorus deficiency (Figure 2). We are currently testing whether these features can be used for phosphorus deficiency selection in the future.
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. Since this populations have a correlation with the sensitivity to the specific plant hormones, the correlation studies with hormone sensitivity are expected.
4. Metabolome analysis and carbon isotope ratio analysis has been started for the heat tolerant wheat lines to reveal the mechanism of tolerance using Liquid Chromatography Mass Spectrometry (LC-MS) and Isotope Ratio Mass Spectrometry (IR-MS). Also, this experimental system is used for the analysis of drought tolerance in wheat.

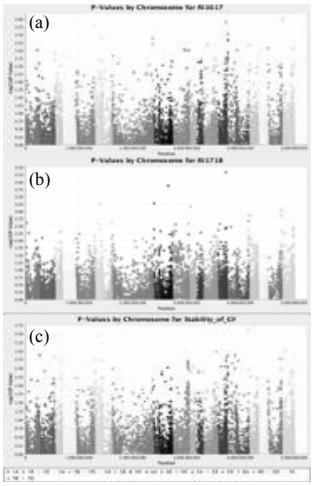


Figure 1. Location of phosphorus resistance genomic markers in GWAS analysis.
(a) and (b) are resistance index markers in Season I and II respectively.
(c) is another tolerance evaluation for combined two seasons using Finlay-Wilkinson model.

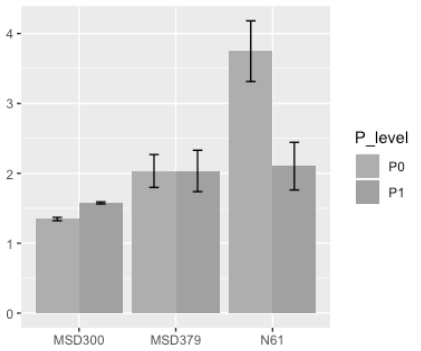


Figure 2. Quantification of the element in response to phosphorus deficiency soil (P0). The susceptible line (N61) accumulated this element under P0 environment while the tolerant lines (MSD300 and 379) didn't show.

Hassan Mohamed Fahmy Abdelbaki (Project Researcher, Agricultural Production)

The subject of the main research activities includes the followings:

(1) Optimizing irrigation depths that maximize net income using the numerical model of crop response to irrigation, WASH 2D, and quantitative weather forecast data.

(2) Parameter identification of stress response function under drought and salinity conditions.

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

1. A field experiment for soybeans grown in a sandy soil was carried out in the Arid Land Research Center (ALRC), Tottori University in 2019. A new scheme to determine irrigation depth using two-dimensional transient model of Water, Atmosphere, Solute and Heat (WASH 2D) and quantitative weather forecast. Rather than maximizing water use efficiency, the scheme aims to maximize net income (Fig. 1). The volumetric water price is considered to give farmers an incentive to save irrigation water. The scheme was compared with a tensiometer-operated automated irrigation in terms of net income, irrigation amount and yield. (Fig. 2a).
2. A field experiment for sweet corn was carried out in the Arid Land Research Center (ALRC), Tottori University in 2019. The same scheme was compared with a tensiometer-operated automated irrigation in terms of net income, irrigation amount and yield. Three replicates per treatment were carried out. Each replicate was a ground water lysimeter (Fig. 2b).
3. I carried out a joint research with the International Center for Agricultural Research in the Dry Areas (ICARDA) in Morocco by conducting two experiments as follows:
   - 3.1. A field experiment for fababean was carried out in the Merchouch Research Station, ICARDA, Rabat, Morocco in the winter season 2019/20. The same scheme was compared to rain-fed cultivation and automated irrigation system operated by sensors in clay soil (Fig. 3).
   - 3.2. A pot experiment for fababean was carried out in order to determine parameter values for response function of water and salinity stresses in clay soil (Fig. 3).
4. I was invited by Kafrelshiekh University, Kafrelsheikh, Egypt. This was to give a training course on using the numerical model, WASH 2D to determine economical irrigation depths (Nov., 2019).
5. I attended the Annual Joint Research Conference at the Arid Land Research Center (ALRC) (Dec., 7-8). Oral and poster presentations. The subject was “Optimization of irrigation depths using a growth model and weather forecast”.

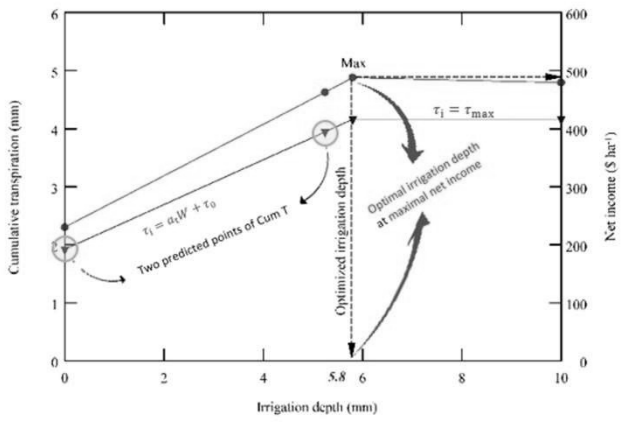


Fig. 1. Example of determining an economical irrigation depth

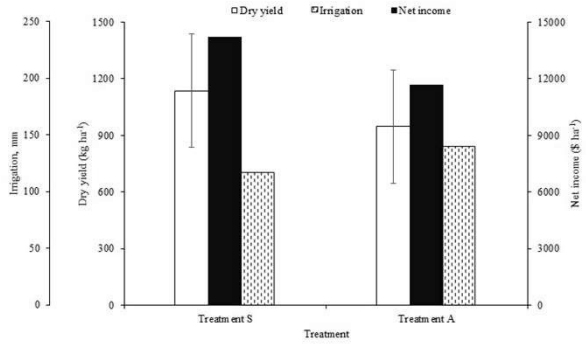


Fig. 2a. Comparison between the proposed scheme and automated irrigation in terms of irrigation amount, yield and net income

Fig. 2b. Sweet corn experiment in ALRC 2019

Fig. 3. Both field and pot experiments carried out in Morocco in the winter season 2019/20.

Jing Wu (Project Researcher, Wind Erosion Climatology)

The wind erosion climatological subdivision conducts research mainly as follows:

(1) Analysis of spatiotemporal characteristics of wind erosion, aeolian dust, and its erosivity (i.e., wind velocity) and erodibility (i.e. land surface condition) by using meteorological data, remote sensing data, and statistic data.

(2) Evaluation of climatic and anthropogenic impacts on dust erodibility.

(3) Estimation of dry season vegetation mass and coverage in the northern Gobi Desert.

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

1. Dust, resulting from wind erosion, is controlled by erosivity (i.e. wind speed) and erodibility (i.e. land surface conditions). Erodibility factor includes various land surface parameters that interact in complicated manners. However, uncertainties remain in clarifying dust emission mechanism due to insufficient observation data of land surface conditions and a lack of understanding of how they impact dust emission. Based on previous studies and our continuous field observation at Tsogt-Ovoo (Mongolia) located in the northern Gobi Desert, we proposed a hypothesis that the summer vegetation could be remained as dead leaves till next spring, thus protecting land surface and suppressing dust emission. Therefore, dry-season vegetation has been recognized as a key parameter in the process of dust emission. However, it still needs quantitative evidence. Also, few studies have dealt with monitoring of dry-season vegetation in the northern Gobi Desert, which is the main source region for Asian Dust. The main purpose of my research during this fiscal year is to estimate dry-season vegetation (dead leaves) coverage and mass through observation data and remote sensing data, and to clarify its influence on dust emission.

2. For estimating dry-season vegetation, field survey was conducted in the early May and September 2020 at Tsogt-Ovoo (hereinafter as TsO) with the cooperation of Dr. Gantsetseg Batdelger of Information Research Institute of Meteorology, Hydrology and Environment, Mongolia (IRIMHE). To measure vegetation coverage, we took photos by digital camera and a drone (MAVIC Pro Platinum) carrying camera of Sentera Single NDVI. We then extracted vegetation coverage from digital photos though image analysis (Fig. 1). Vegetation coverage by eye was also obtained by Dr. Gantsetseg. To measure vegetation mass, we cut aboveground mass within 1m×1m quadrat (Fig. 2). Dr. Gantsetseg brought all vegetation samplings to Ulaanbaatar and measured mass after drying them in an oven.

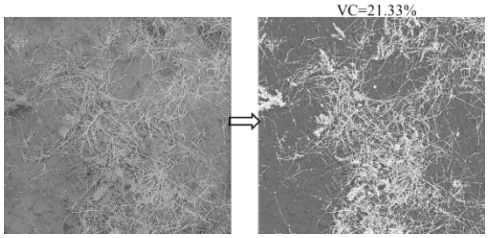


Fig. 1 Extraction of vegetation coverage from digital photos by image analysis.

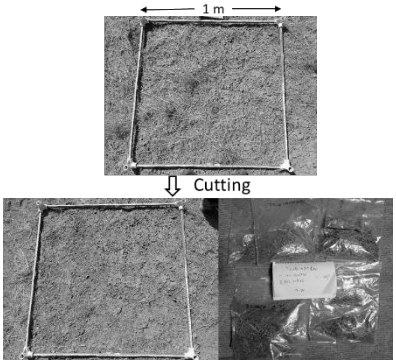


Fig. 2 Collection of aboveground vegetation mass within a 1m×1m quadrat.

3. In terms of remote sensing data, I examined Normalized Difference Vegetation Index (NDVI) by using MODIS/Terra Vegetation Indices Global products as well as Soil Tillage Index (STI), which is a potential representative index for dry-season vegetation by using MODIS Nadir BRDF-adjusted reflectance products around Tsogt-Ovoo (Fig. 3). The spatial resolution of NDVI and STI is 250m and 500m, respectively.

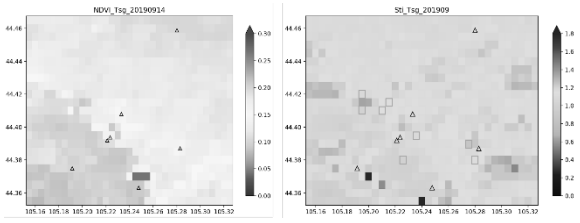


Fig. 3 Spatial distribution of NDVI and STI in September 2019 around Tsogt-Ovoo, Mongolia.

4. To estimate dry-season vegetation mass by using remote sensing data, a regression analysis was carried out between the measured mass and NDVI and STI, respectively (Fig. 4). A significant correlation was found in STI (Fig. 4b, R^2=0.48, $p<0.01$), indicating that STI is suitable for estimating dry-season vegetation mass in the Gobi Desert.

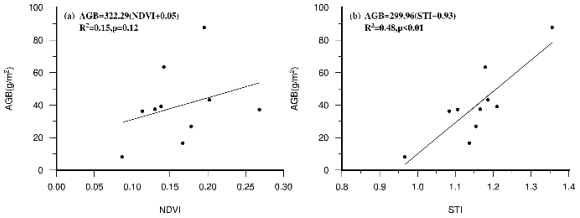


Fig. 4 The relations between dry-season vegetation mass and (a) NDVI, and (b) STI in September 2019 around Tsogt-Ovoo, Mongolia

河合　隆行（地下水水文学）

SATREPS エチオピアプロジェクト（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）における研究一環として、エチオピア高原における年間降水量と地下水環境に関する研究をおこなった。具体的な現地観測等は以下のとおりである。

1．雨粒測定のためのディストロメータ装置を導入し、次年度の雨期に向けての観測態勢を整えた。降水の粒径と落下速度を計測する本装置にはデータロガおよび停電対策装置を備えており、現地での数ヶ月に及ぶ雨期中の観測が可能になる。

2．プロジェクトにおける研究代表地点 3 カ所にて、乾期の地下流水音探査を実施した。地下流水音測定の研究目的は 2 点あり詳細は以下の通り。1 点目は地下流水音の加速度データを用いて土壌中の飽和帯と不飽和帯の境界深度を推定し、測定時の地下水位を得ることである。ここで得られる結果から、井戸等の大型施設を設けることなく地域の地下水位および水位変動を推定することが可能である。2 点目は地中水の破裂数密度を得ることで、観測地域のガリ侵食ポテンシャルを評価することである。得られる結果から測定地点の水みち活性度が明らかになるため，ガリ発達のポテンシャル評価が可能となる。ガリ既存のサイトにおいて、規定の観測密度にて破裂数観測を実施し、サイト内の将来的なガリ侵食発達図を作成することを最終目的としている。

Fig.1 Groundwater aeration sound observation

Fig.1 に 2019 年 11 月に実施した地下流水音測定の様子を示す。また、図 2 に 3 つの標高の異なる研究サイトにおける地下流水音の加速度データを示す。なお，3 サイトは高地を代表するグダル（標高 2700m 前後）、中間地を代表するアバガリマ（標高 2100m 前後）、低地を代表するドゥバテ（標高 1500m 前後）となっている。Fig.2 より、高・中標高の 2 地点では平均的に加速度が大きく地下水位が浅いことが示される。また、低地のドゥバテでは小川の周辺以外では非常に加速度が小さく、地下水位が数 10m ほどの深部にあるか、あるいは全く存在しないことが示された。乾期のこの観測結果は、高～中標高 2 地点は第四紀の未分化地質かつ山がちな地形であること、低地ドゥバテのみ 5-7 億年前に堆積した固結の進んだ玄武岩質の地質であり降水浸透能が非常に低いと予想される、という水文地質学的視点とも合致している。

Takayuki Kawai (Project Researcher, Groundwater Hydrology)

As a part of the SATREPS Ethiopia project (Development of next-generation Sustainable Land Management framework to combat desertification), the annual rainfall and groundwater environment in the Ethiopian plateau was studied.

1. A set of distrometers for raindrop measurement was installed and prepared for the next year's rainy season. This device, which measures precipitation droplet size and fall rate, is equipped with a data logger and a power failure countermeasure system.

2. Groundwater aeration sound (GAS) surveys were conducted at three sites in the project. The purpose of the study of GAS measurement is twofold. The first is to estimate the boundary depth between the saturated and unsaturated zones in the soil using acceleration data of GAS, and to obtain the groundwater level. This result makes it possible to estimate the regional groundwater level and water level variation without the installation of large facilities such as wells. The second is to evaluate the galley erosion potential by obtaining the burst number density of GAS. The results clarify the water passage activity at the measurement site and thus enable us to evaluate the potential for gully development.

Fig. 1 shows the GAS measurements observed in November 2019. Figure 2 shows GAS acceleration data for three different study sites at different elevations. The three sites are Gudar (around 2700m MSL) at highlands, Aba gerima (around 2100m MSL) at middlelands, and Dubate (around 1500m MSL) representing the lowlands. Fig. 2 shows that the average acceleration is higher at two sites of high to middle elevation and the groundwater level is shallower. In the lowland Dubate, the acceleration was very low except around the streams, indicating that the groundwater level was quite deep or non-existent. These results are consistent with the hydrogeological viewpoints that the two sites at high to middle elevation have undifferentiated Quaternary geology and mountainous terrain, and that only the lowland Dubite has a consolidated basaltic geology deposited 500-700 million years ago and has a very low rainfall infiltration capacity.

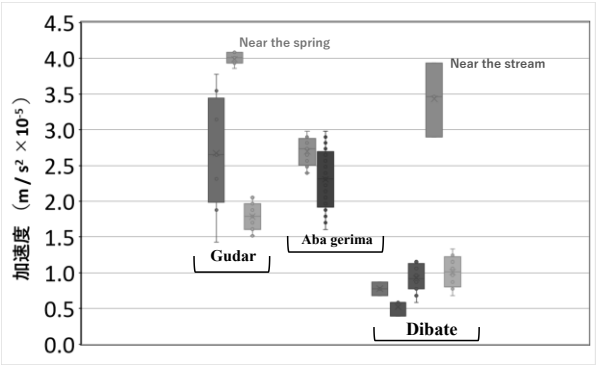


Fig.2 Acceleration distribution of groundwater aeration sound

Ayele A. Fenta (Project Researcher, Integrated Desertification Control)

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

(1) Estimate changes in ecosystem services value (ESV) in the wake of land cover change in sub-Saharan Africa (SSA) using the European Space Agency Climate Change Initiative land cover maps (1992–2015) and the value transfer method using global valuation coefficients;
(2) Quantify the losses in ESV due to land degradation by employing long-term (1992–2015) trends in the annual normalized difference vegetation index (NDVI) as a proxy for long-term biomass productivity decline; and
(3) Analyze the losses and gains in ESV across sub-regions, climate zones, and countries of the SSA region to identify areas where prominent changes in ESV have occurred.

In this fiscal year, the following are the main extracts of the research findings:

1. Between 1992 and 2015, cropland increased by about 20 million ha, largely at the expense of forest and shrubland (Fig. 1).

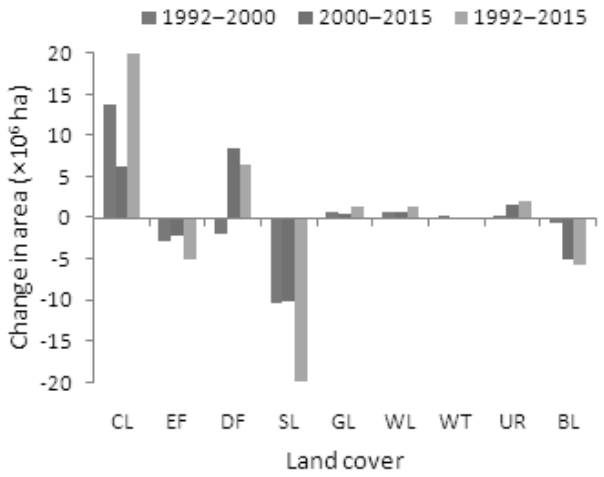


Fig. 1 Estimated changes in areas of land cover over SSA: CL cropland, EF evergreen forest, DF deciduous forest, SL shrubland, GL grassland, WL wetland, WT waterbodies, UR urban. BL bareland.

2. The total estimated ESV of SSA was about US$9 trillion year^{-1}, of which 55% was derived from cropland and deciduous forest, with comparable contributions (Table 1).

Table 1. Estimated ESV (2007 price levels).

	ESV (billion US$ yr^{-1})		
Land cover type	1992	2000	2015
Cropland	2,367	2,444	2,479
Evergreen forest	1,069	1,053	1,042
Deciduous forest	2,355	2,345	2,389
Shrubland	749	732	716
Grassland	854	856	857
Wetland	1,184	1,202	1,220
Waterbodies	127	128	127
Total	**8,705**	**8,760**	**8,830**

3. Land cover change resulted in a net increase in the total ESV by US$125 billion year^{-1} (1992–2015), albeit with an ESV loss of US$60 billion year^{-1} from the conversion of evergreen forest and shrubland (Fig. 2).

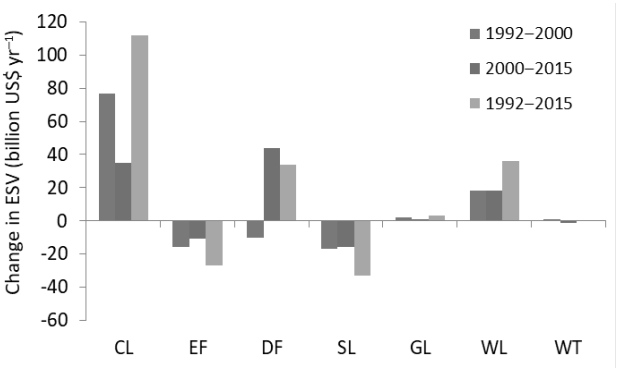


Fig. 2 Estimated changes in ESV over SSA: CL cropland, EF evergreen forest, DF deciduous forest, SL shrubland, GL grassland, WL wetland, WT waterbodies, UR urban, BL bareland.

4. Overall, cropland expansion accounted for about 60% of the increase in the total ESV (US$125 billion year^{-1}), thereby outweighing the decrease in ESV due to the decline in natural vegetation.
5. Land degradation hotspots covered about 5% of SSA (Fig. 3), resulting in a total ESV loss of about US$56 billion year^{-1}, of which nearly 65% was due to the degradation of forests and croplands.

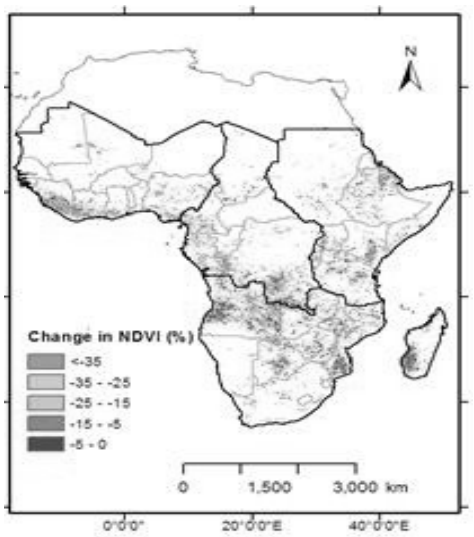


Fig. 3 Long-term change in annual NDVI (%) as a proxy for long-term biomass productivity decline (land degradation); only pixels that exhibited statistically significant changes ($P < 0.1$) are shown.

6. Changes in ESV varied across sub-regions, climate zones, and countries, depending on the dominant land cover change and the extent of land degradation.

Kindiye Ebabu Gelaw (Project Researcher, Soil Erosion and Sustainable Land Management)

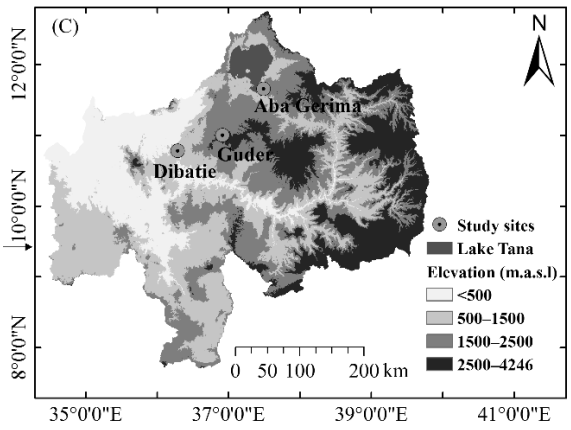
The soil erosion and sustainable land management subdivision conducts research on: Effects of land use and management practices on runoff, soil loss and soil quality properties in three different sites at plot and watershed scales in the drought prone areas of the Upper Blue Nile basin of Ethiopia.

In the fiscal year 2019, I carried out activities on the topic: "Exploring the variability of soil properties as influenced by land use and management practices". In doing so, I analyzed nine soil quality indicator physical and chemical properties — texture, bulk density (BD), pH, electrical conductivity (EC), cation exchange capacity (CEC), total nitrogen (TN), soil organic carbon (SOC), available phosphorus (Pav), and available potassium (Kav) — for topsoil (0–20 cm) samples collected from experimental plots established for monitoring runoff and soil loss rates at three different sites (Aba Gerima, Guder, and Dibatie) in different land use types (cropland [CL], grazing land [GL], and bushland [DBL]) with different SLM practices (*fanya juu* [F] and soil bund reinforced with grass [SBG] for croplands, and exclosure [E] and exclosure with trenches [E+T] for grazing land bushlands).

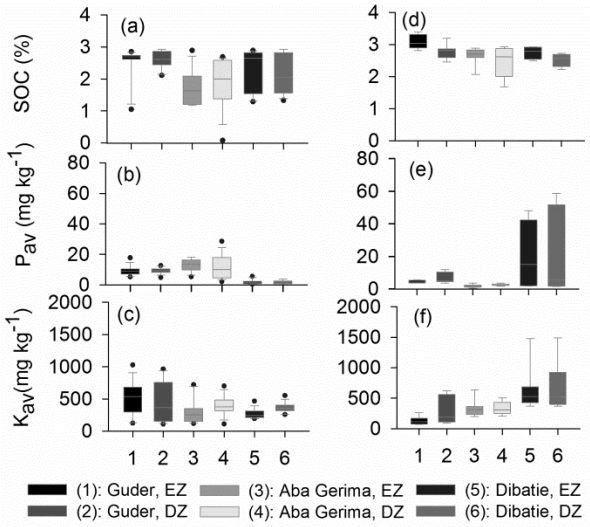
The results showed that seven of the nine studied soil properties significantly differed among three land use types in the three sites. In all three sites, the amounts of pH, CEC, SOC and TN in soils of cropland were far lower than those in soils of grazing land and bushland, and this is more pronounced at the Aba Gerima site in the mid-land agro-ecological zone of the basin largely due to high rainfall intensity and soil loss rates.

To understand the effects of sustainable land management (SLM) practices on spatial and temporal changes in soil quality properties, analysis was done considering two sampling periods (before and after SLM) and zones (erosion versus deposition zones along the slope in plots with structural SLM practices).

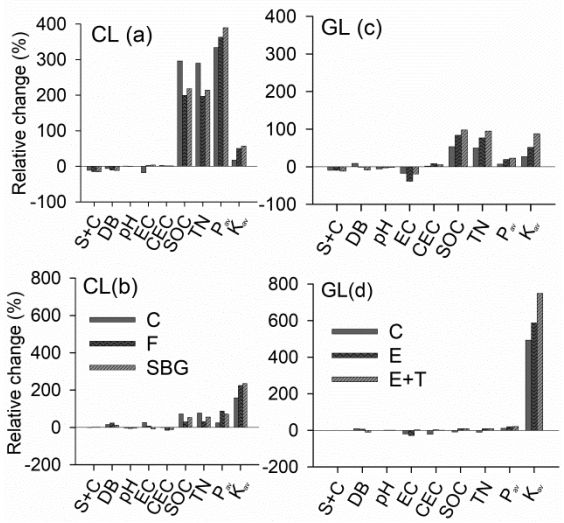
The results demonstrated that sensitive soil properties (BD, SOC, TN, P_{av}, and K_{av}) showed remarkable improvement three years after the implementation of SLM practices, and clear variation between erosion and deposition zones in plots where in structural SLM practices (F, SBG, and E+T) were implemented. Such a remarkable improvement in sensitive soil properties was linked to the development of vegetation cover.



Location of the three sites in the Upper Blue Nile Basin of Ethiopia. Dibatie, Aba Gerima, and Guder, respectively, represent the lowland, midland, and highland agro-ecologies.



Box-and-whisker plots showing variations in soil organic carbon (SOC), available phosphorous (Pav) and available potassium (Kav) in soil samples collected from erosion zones (EZ), and deposition zones (DZ) along the slope in cropland plots with *fanya juu* and soil bunds reinforced with grass (a–c), and non-cropland plots with trenches under exclosure (d–f) at Guder, Aba Gerima, and Dibatie.



Relative changes in soil properties three years after the implementation of different management practices in croplands (CL) and grazing lands (GL) at Aba Gerima (a & c) and Dibatie (b & d). The relative change values represent the ratio of the difference in actual values between after (in 2018) and before (in 2015) SLM to the actual values obtained in 2015 (baseline). C: control; S+C: silt and clay.

I attended the International Conference: AGU Fall meeting, which was held in San Francisco, California, USA, during 9-13 December 2019. On this conference I presented a poster entitled "Runoff, Soil loss, and soil properties as influenced by land use and management practices: Case study from the Upper Blue Nile basin, Ethiopia". During the conference, I obtained new ideas and methods useful for current and future studies towards sustainable land management through controlling soil erosion and improving soil quality attributes in the drought prone areas.

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：辻本壽）

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。

令和元年度、3 件の共同研究（継続課題）が開始した。7 月 12 日、各共同研究課題と各グループのメンバーが集まり、国内会議を実施した。12 月 6 日、スーダンとモンゴルの研究者 3 名を招き、第 3 回国際ワークショップ「気候変動の乾燥地へのインパクト：影響評価と適応策」を開催した。また、令和 2 年度共同研究（新規課題）の公募を行い、3 件の課題を採択した。

(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: Tsujimoto, H.)

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 2019, three subjects of collaborative research (continued) started. A domestic meeting was held on July 12th. ALRC held the 3rd International Workshop, inviting three researchers from Sudan and Mongolia. It publicly offered new subjects of collaborative research for FY 2020, and it adopted three subjects.

（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：
5 年間（平成 29 年度～令和 3 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。

令和元年度は、人間活動と気候変動に対する水文学的応答および堆積物応答のモニタリング、生物物理的手法及び土壌改良剤を用いた土地管理が土壌侵食の削減に及ぼす効果の評価、「教会の森」由来の土壌微生物を用いた劣化地での在来樹種の実生定着手法を継続して実施した。11 月に現地で合同調整委員会（JCC）及び中間評価会を開催し、JICA より 6 項目からなる Recommendation を受けた。さらに 1 月末には、JST による中間評価を受け、総合評価で A 評価を受けた。

(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

Research Period
FY 2017 - FY 2021 (five 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 2019, we conducted research on modeling 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 role of soil microbes from remnant Church Forest to assist seedling establishment of native tree species in a degraded land. In November, a Joint Coordinating Committee (JCC) and an interim evaluation meeting were held in Ethiopia, and we received recommendations from JICA including 6 items. In addition, at the end of January, we also received an interim evaluation by JST and were given an A rating.

（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。

令和元年度は、スーダンの政権交代による治安悪化により、外務省がスーダンの危険レベルを 1 から 3 に引き上げた。このため、スーダンのプロジェクト関係者を日本に招聘してキックオフ会議を開き、今後の対応方針を検討した。その後、レベルが 2 に緩和されたため、コムギの栽培実験を行い、高温乾燥条件におけるコムギの評価を行った。令和 2 年 3 月には延期していた合同調整委員会（JCC）を開催し、今後の研究方針を決定した。

(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)

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 FY 2019, due to deteriorating security situation caused by regime change in Sudan, Japanese Ministry of Foreign Affairs raised the risk level of Sudan from 1 to 3. As the result, we invited the project members to Japan for the kick-off meeting to discuss the response policy of this project. Subsequently, as the risk level was relaxed to 2, all experiments were conducted as planned. We sowed wheat seeds, cultivate, and evaluated the heat and drought stress tolerance in the stressed field in Sudan. In March 2020, the postponed Joint Coordinating Committee (JCC) was held to evaluate the future research policy.

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	谷口　武士 Taniguchi, Takeshi
研究代表者 Principal Researcher	片岡　良太（山梨大学大学院総合研究部生命環境学域） Kataoka, Ryota (Graduate Faculty of Interdisciplinary Research, University of Yamanashi)		
研究課題 Research Subject	トルコ国内の塩生植物に内生する微生物群集と塩類集積土壌のファイトレメディエーションに関する研究 The research on endophytic microbial community of halophytic plant and its application to phytoremediation of salinity soils in Turkey.		
共同研究要旨 Summary of Joint Research	This year, Na tolerance, Na absorption and endophytic stracture of *Mesembryanthemum* plants were investigated. *M. crystallinum* used in this study used commercial seeds, and *M. chilensis* was collected along the coast of Tahara City, Aichi Prefecture. *M. edule* was collected along the Aegean Sea in western Turkey (Kusadasi, Datca, and Marmaris). A Na tolerance was performed using the above three *Mesembryanthemum* plants. *M. crystallinum* was grown using three types of soil (andisol, lowland soil, and brown forest soil) by adjusting the soil so that the Na concentration was 50 mM, 200 mM, and 350 mM. For *M. chilensis* and *M. edule*, the Na concentration in soil was adjusted to 50 mM, 100 mM, 200 mM, 400 mM, and 600 mM, and grew them. Growth of *M. crystallinum* and *M. chilensis* is carried out in the artificial climate chamber (temperature: 20 ° C, humidity: 70%) of the University of Yamanashi for 80 days. After the cultivation, the fresh weight and the dry weight were measured. Then, as an evaluation of Na uptake, the dried plant was grounded, and 0.5 g of the plant was added with a 10% aqueous nitric acid solution and subjected to heating decomposition. The digested solution was filtered after dilution, and conducted to MP-AES analysis. The results of the pot experiment revealed that *M. crystallinum* showed the same growth at a Na concentration of 200 mM as at a Na concentration of 50 mM (control). However, the growth was significantly suppressed under the condition of a Na concentration of 350 mM. On the other hand, although *M. chilensis* and *M. edule* have been reported to be closely related to each other, they showed significant differences in Na tolerance from this test. *M. chilensis* grew vigorously up to a Na concentration of 100 mM, but showed rapid growth inhibition at a Na concentration of 200 mM or more. In contrast, *M. edule* grew better on Na-containing soils than on Na-free soils, and grew without inhibition at 600 mM. In addition, the results of the Na uptake revealed that the Na concentration in *M. crystallinum* tended to increase in response to the Na concentration in soil. However, under the condition of the Na concentration of 350 mM, the plant was small, so that the Na amount per plant was low. In *M. chilensis*, when planted at a Na concentration of 600 mM, the Na concentration in the plant reached 150,000 mg / kg. However, the Na concentration in *M. edule*, which grew well under high Na concentration, lower at a maximum of 27,000 mg / kg than *M. chilensis*.		

特定研究 2 Specific Research 2		対応教員 Corresponding Staff	石井　孝佳 Ishii, Takayoshi
研究代表者 Principal Researcher	岡本　龍史（首都大学東京理学研究科） 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	Establishment of wheat IVF system promotes the access to hybridization and allopolyploidization which have long been recognized as a decisive role in plant evolution and diversification. However, mechanism in hybridization largely remains open due to limitations in production of hybrid zygotes. By utilizing IVF systems with wheat and rice gametes, combinations of wheat-rice hybrid zygotes were produced and classified into three groups, (1) Wheat-rice hybrid zygotes possessing wheat sperm components, (2) Wheat-rice hybrid zygotes possessing rice sperm components and (3) Wheat-rice double zygotes, and the developmental profiles of these intergeneric zygotes were monitored. In most combinations, hybrid zygotes arrested at multicellular or one-celled stage. However, notably, hybrid		

	zygotes possessing several wheat-rice intergeneric gamete combinations divided and developed to plantlets, although elimination of rice genome appeared to occur during zygotic development. The elimination of rice genome in wheat-rice hybrids was consistent with wheat-like morphological characteristics of the hybrid plants, and I am trying to visualize rice-chromosome elimination process during development of hybrid zygote using RGEN-ISL method. In addition to these cytogenetic analyses, the hybrid plants were applied to genome DNA sequencing. The preliminary results suggested that fragmented rice nuclear genomic DNA and wide rice mitochondrial DNA regions are likely to be integrated in wheat nuclear and mitochondrial DNAs in wheat-rice hybrids. In addition to wheat-rice hybrid zygotes, wheat-maize hybrid zygotes were also produced, and the hybrid zygotes also developed into wheat-like plants with haploid genome set. This suggests that maize genome was eliminated during the development of the wheat-maize hybrid zygotes.

(2) 重点研究 /Focused Research

重点研究 1 Focused Research 1		対応教員 Corresponding Staff	山中　典和 Yamanaka, Norikazu
研究代表者 Principal Researcher	川田　清和（筑波大学生命環境系） Kawada, Kiyokazu (Faculty of Life and Environmental Sciences, University of Tsukuba)		
研究課題 Research Subject	バイオマニピュレーションによる半乾燥地の生態系シフトを用いた環境修復 Environmental restoration using ecological shift of semi-arid region by bio-manipulation		
共同研究要旨 Summary of Joint Research	A follow-up study was conducted on the establishment of Stipa krylovii by biomanipulation (tiling (P), fertilization (F), sowing (S), irrigation (W)). In the FPSW treatment group, 72.8 ± 42.4% of the individuals germinated in September 2017 survived until September 2019. In addition, the germinated individuals showed high survival rates over the severe winter season, suggesting the effectiveness of soil improvement by biomanipulation. As an operation to promote the growth of germinated individuals, a soil improvement test was performed in which livestock dung was mixed with the soil after plowing. As a result, the concentration of nitrogen ions in the soil was increased by mixing animal dung with the plowed soil. However, the germination rate was lower than the control when plowed. This was probably due to eating by wild animals. When the germinated individuals showed signs of biting, the rate of erosion in the treated plots was over 80%. The result of this study suggested that abandoned cultivated land can be shifted to an original ecosystem by biomanipulation, and may be able to restore original composition from abandoned cultivated land to original grassland. On the other hand, it was suggested that increasing the tillage scale could induce feeding damage by wild animals. In the future, we need to examine tillage methods that do not increase the rate of erosion, and consider more effective restoration methods for abandoned cultivated land.		

重点研究 2 Focused Research 2		対応教員 Corresponding Staff	恒川　篤史 Tsunekawa, Atsushi
研究代表者 Principal Researcher	土本　卓（大阪大学薬学研究科） Tsuchimoto, Suguru (Graduate School of Pharmaceutical Sciences, Osaka University)		
研究課題 Research Subject	乾燥地の産業用油料作物に関する生産と利用の研究 Study on production and application of industrial oil crops for arid lands		
共同研究要旨 Summary of Joint Research	A jojoba test field of 4.2 ha was set up in the desert about 100 km northwest of Cairo. About 4,000 Egyptian good female cuttings, about 1,000 Egyptian seedlings, etc. were cultivated from August 2017 by using drip irrigation with groundwater with 300 ppm of salinity. We measured plant height and width from November 2019 to January 2020 and showed that the average height and width were 102 cm and 134 cm, respectively. By comparing the height of same plants between February and November of 2019, we showed that the average growth rate of the plants during the period was 72%. We also examined 1430 plants for fruiting in the 2019/20 season and flowering in the 2020/21 season, the fruiting rate in 2019/20 was 61%, and the rate in cuttings was more than two times higher than that in seed-		

	lings. The flowering rate in 2020/21 was 91%, and the rates in cuttings and seedlings did not have significant difference. We will examine individual seed yields by setting nets in the summer of 2020. We are also doing trial cultivation of 11 USDA strains at OU, ALRC, etc. and got fruits as last year. We extracted genomic DNA from leaves of a USDA strain grown at OU, and did the genomic DNA sequencing in last fiscal year. In this fiscal year, we assembled the data and got the jojoba genomic sequence of 768 Mbp. The genome size was estimated as 908 Mbp. To use for DNA markers, we identified 7.2 million SNPs and 410 thousand Indels. We also did gene annotation. We showed that the oxidation stability of jojoba oil was significantly higher than other vegetable oils, such as olive oil, and that crude jojoba oil did not have skin irritancy by MTT assay using the 3D skin model. The elite Jatropha strain of Mexico was not transferred to Japan and its research could not be done. In this fiscal year, we published a paper on cultivation of jojoba in Egypt.

重点研究 3 Focused Research 3	対応教員 Corresponding Staff	藤巻　晴行 Fujimaki, Haruyuki
研究代表者 Principal Researcher	永淵　修（福岡工業大学総合研究機構） Nagafuchi, Osamu (Comprehensive Research Organization, Fukuoka Institute of Technology)	
研究課題 Research Subject	モンゴル高原における地下水中微量物質および病原細菌によるヒト健康リスク評価とその削減対策 Human Health risk assessment caused from trace elements and pathogenic bacteria in ground water and its reduction technology in Mongolian plateau	
共同研究要旨 Summary of Joint Research	In 2019, we could not go out for field survey in Mongolia. We performed further chemical analysis which we sampled before. Result of human health risk analysis F^- and as concentration in groundwater may human health concern. Based on the scenario analysis, in order to reduce risk concern of F^- and as in groundwater, our result suggest that if they use snow in winter then there is a possibility that they reduce risk concern. There were no geophysical characteristics of F^- and as concentration in groundwater. Also, there were no relationship between concentration and well depth. Here, in order to reduce human health risk concern from the viewpoint of geophysical aspect, we examined the similarity between the sites based on the water quality of the well water in M village. The similarity between points was examined by (1) major ion concentrations, (2) metal concentrations, and (3) rare metal concentrations, respectively. Numerical values were normalized by the ratio of each component to all components, and cluster analysis (dendrogram) was performed using Distance Index. Then, the K-mean method was used to perform three divisions. As a result, 57.8%, 45.0%, and 98.3% by constitutes of the components1 and 2 could be explained. Therefore, normalization was performed using the values of rare metals in meteorites, and the same analysis was performed. As a result, 99.56% could be explained for components 1 and 2. According to the classification based on the similarity, the wells of groups 2 and 3 almost coincided with the high concentration wells (high risk wells).	

（3）一般研究 /General Research

一般研究 1 General Research 1	対応教員 Corresponding Staff	辻本　壽 Tsujimoto, Hisashi
研究代表者 Principal Researcher	伊藤　秀臣（北海道大学大学院理学研究院） Ito, Hidetaka (Faculty of Science, Hokkaido University)	
研究課題 Research Subject	高温活性型トランスポゾンを用いた乾燥耐性植物の作出 Creation of a drought-tolerant plant by a heat-activated transposon	
共同研究要旨 Summary of Joint Research	In this study, in addition to the Arabidopsis, we analyzed soybeans and adzuki beans of legumes, for which genomic information is available, and analyzed them using high-temperature-activated transposons named ONSEN. By the previous year, based on the information on the ONSEN identified in Arabidopsis, we searched for ONSEN in soybean and adzuki beans by homology search and expression analysis. Based on these genomic information, we identified ONSEN that can be transposed by performing high-temperature treatment on soybeans and adzuki beans, and induced transposition of endogenous ONSEN present in soybeans and adzuki beans. For the induction of transposition, a tech-	

	nique established in previous studies using Arabidopsis was applied, and a technique for de-differentiating plant tissues and redifferentiating callus was used. The callus of plant tissue treated at high temperature induced the transposition of ONSEN. However, the method established in the previous study has a low transposition frequency, so we devised to increase the transposition frequency. Specifically, we attempted to increase the transposition frequency by increasing the amount of transposon transcription by inducing callus formation after the treatment with the DNA methylation inhibitor zebularine. To investigate the effects of zebularine, we first performed transposon induction analysis using Arabidopsis. As a result, the callus of Arabidopsis treated with zebularine was subjected to high-temperature stress, high frequency of transposition was observed, and an increased the copy number of ONSEN. Similarly, analysis using soybean showed that the amount of ONSEN transcribed in soybean was not significantly changed by the treatment with zebularine. In the future, in order to increase the frequency of transposition in soybean and adzuki bean, it is necessary to devise ways such as the time of high temperature treatment, the method of callus formation and the type of DNA methylation inhibitor.

一般研究 2 General Research 2	対応教員 Corresponding Staff	黒崎　泰典 Kurosaki, Yasunori
研究代表者 Principal Researcher	長田　和雄（名古屋大学環境学研究科） Osada, Kazuo (Graduate School of Environmental Studies, Nagoya University)	
研究課題 Research Subject	長距離輸送される黄砂・$PM_{2.5}$ など大気エアロゾルの観測 Observation of long-range transported atmospheric aerosols such as Kosa and $PM_{2.5}$	
共同研究要旨 Summary of Joint Research	The size-segregated mass concentrations of atmospheric aerosols were observed by using the PM712 at the roof of the ALRC. The results from April 2013 to November 2019 are shown in Fig. 1. PM2.5 represents particles having diameter of 2.5 μm or less, and PMc represents coarse particles having diameter of 2.5 to 10 μm. Transport of KOSA dusts was not so often during the past several years, including 2019. However, from October 30 to November 2 in 2019, autumn KOSA was observed for the first time in six years. The results of chemical analysis of the size segregated tape filter samples of PM712 from August 2015 to June 2018 showed clear seasonal variations in ammonium and nitrate concentrations. The sulfate concentration during winter to spring gradually decreased for the study period, which is probably due to changes in emission reductions in China. This year, we applied newly developed provenance-tracing method using cathodoluminescence (CL) spectral analysis of single quartz grains (Nagashima et al., 2016) to the water filtering samples from the Northwestern Pacific. The CL spectra of quartz grains in several filtering samples show dominance of quartz grains from Gobi and Taklimakan Deserts, while other samples show different spectra patterns from Gobi/Taklimakan Deserts. We'll further examine the conditions required for long-distance transport of dust from East Asia to the Northwestern Pacific.	

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	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	アポカロテノイド植物ホルモンに着目した根寄生雑草ストライガの生存戦略の解析 Functional analyses of apocarotenoid phytohormones as key factors in adaptability of *Striga* species to parasitic mode of life	
共同研究要旨 Summary of Joint Research	*Striga hermonthica*, an obligate root hemi-parasitic angiosperm, is a major biological constraint to cereal production in sub-Saharan Africa. The transpiration gap between *Striga* and the host plant is presumed to accelerate diversion of water and nutrients to the parasite. In general, drought stress induces stomatal closure in terrestrial plants, suppresses transpiration and thereby reduces water consumption. In contrast, *Striga* maintains opened stomata and high transpiration even under water deficit. Recently, we revealed that the abnormal stomatal behavior resides on an aberrant protein phosphatase designated as ShPP2C1, which induces loss of sensitivity to abscisic acid (ABA) in *Striga*. During the course of the study, we found that ABA level in *Striga* seeds was negligible before germination, whereas high concentrations of ABA were detected in the seedlings, indicating that *Striga* is able to synthesize ABA independently. Further analysis revealed that ABA production and exudation by *Striga* seedlings increased drastically subsequent to germination. The facts that *Striga* germinates in close	

	proximity of its host roots and a considerable proportion of the ABA produced by the parasite seedlings is exuded in the host rhizosphere suggest that ABA exuded from *Striga* seedlings could, at least in part, reduce growth and contribute to the bewitching effects the parasite inflicts on its host at the early stages of their interactions.

一般研究 4 General Research 4		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	中国黄土高原の乾燥傾度に沿った土壌微生物機能群の変化 Changes in microbial community and its functions along a precipitation gradient in Loess Plateau, China		
共同研究要旨 Summary of Joint Research	Soil microbial community and its function could be affected by aridity level, particularly in an arid area. The aim of this study is to investigate the effects of precipitation on soil microbial community related soil N cycling in the semi-arid forest on in Loess Plateau, China. In this study, we investigated the change in the microbial community and its function concerning N cycling on semi-arid forests along the precipitation gradient. Soil samples of black locust plantations were collected from three different regions where precipitation ranged from 450 to 600 mm. We measured soil chemical properties including dissolved N contents and also measured the abundance and composition of the soil microbes using the q-PCR and the next-generation sequencer. We also predicted the microbial functional group of each forest by the predicted metagenome methods using ITS and 16S based community data. We found the aridity level had a big impact on soil N transformation processes such as degradation of high-molecular-weight organic matter, mineralization, and nitrification, as increasing aridity reduced all the extractable N contents. However, the microbial group governed each step of responded in different ways. The study suggested the nitrification step is the most sensitive process to decreasing rainfall because the abundance of ammonia-oxidizers was primarily determined by soil moisture although the remaining two steps were likely to be determined by quantity and quality of substrates.		

一般研究 5 General Research 5		対応教員 Corresponding Staff	恒川　篤史 Tsunekawa, Atsushi
研究代表者 Principal Researcher	坂本　敦（広島大学大学院統合生命科学研究科） Sakamoto, Atsushi (Graduate School of Integrated Sciences for Life, Hiroshima University)		
研究課題 Research Subject	アラントインのプライミング作用による低温馴化と凍結耐性の向上 Enhanced cold acclimation and freezing tolerance mediated by the stress priming effect of allantoin		
共同研究要旨 Summary of Joint Research	Allantoin is an intermediary metabolite in purine degradation which often accumulates in a broad spectrum of plants under various environmental stresses. We previously showed that allantoin can prime abiotic stress responses in *Arabidopsis thaliana*, at least by moderately activating abscisic acid and jasmonate production. As a result, allantoin-accumulating mutants of Arabidopsis exhibited enhanced tolerance to drought and osmotic stress. Microarray analysis of the mutants suggested that allantoin can also mitigate cold stress because a set of low-temperature-responsive genes moderately increased their steady-state transcript levels at normal temperatures, an indication that the mutants are primed for cold stress. Indeed, the allantoin-accumulating mutants alleviated symptoms of cold injury and significantly increased survival rate after freezing, most probably due to the increased levels of allantoin. Exogenous pretreatment of allantoin to the wild type also enhanced freezing tolerance. Overall, the results showed that allantoin accumulation contributes to freezing tolerance in Arabidopsis.		

一般研究 6 General Research 6		対応教員 Corresponding Staff	辻本　壽 Tsujimoto, Hisashi
研究代表者 Principal Researcher	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	アブシシン酸の感受性を利用した節水型耐乾性コムギの選抜と分子生理学的解析 Isolation and molecular characterization of water-saving wheat by abscisic acid sensitivity		

共同研究要旨 Summary of Joint Research	Genetic diversity of wheat is poor compared to other major crops, and it is a major barrier to modern wheat breeding. To overcome this defect, Prof. Tsujimoto has been generated wheat multiple synthetic derivatives (MSD) populations, which have variation of D genome from many accessions of *Aegilops tauschii*. Using this resource, we aimed to isolate water-saving and drought tolerant wheat. So far, approximately 20,000 individual seedlings of MSD have been tested for the sensitivity to the plant hormone abscisic acid (ABA), which is known as a key small molecule for drought tolerant, and we have been isolated ABA-hypersensitive strains. Among ABA-hypersensitive MSD lines, many ABA-hypersensitive strains were derived from primary synthetic No.40 wheat line, which is originated KU-2098 accession of *Aegilops tauschii*. These results indicate that several parts in the D genome of KU-2098 accession might be involved in ABA sensitivity. To determine the loci controlling ABA sensitivity in the D genome of KU-2098 accession, F2 seedlings of Norin 61 and major ABA-hypersensitive MDS strain named as Oka28 line have analyzed by next generation sequencing of DArT company. However, we could not find obviously common loci in the D genome among ABA-hypersensitive lines after ABA sensitivity test using F2 seedlings. This cause was attributed to the fact that the ABA sensitivity test using 2F seedlings contained many false positives. Therefore, we decided to take a strategy to identify the QTLs that control ABA sensitivity by using F3 seedlings, which are fixed genetic properties.

一般研究 7 General Research 7	対応教員 Corresponding Staff	黒崎　泰典 Kurosaki, Yasunori
研究代表者 Principal Researcher	鹿島　薫（九州大学大学院理学研究院） Kashima, Kaoru (Faculty of Science, Kyushu University)	
研究課題 Research Subject	モンゴル・アルタイ山地における湖沼環境と気候・風成塵（黄砂）の長期的変動 The long-term fluctuations of lake environment, climate and aeolian dusts (KOSA) at Altai Mountain in Mongolia	
共同研究要旨 Summary of Joint Research	Recover of Water Resources and their future prediction were the base of the anti-desertification. The purpose of the project was to presume long-term changes of water resources in Mongolia using geologic and geomorphologic methods. The long-term change of water resource was not uniform in Mongolia. For example, the survey at the lake side pond at Lake Khuvsgul, our previous survey, north-west Mongolia, presumed the two low lake level stages, -4m level at 2500 yBP and -2m level 1000-1500 yBP. After then, lake level increased till now. The increasing of lake level has still continued. On the other hands, Khudel Peat Land, our other previous survey area, north central Mongolia, has continued to accelerate dry environment since 2500 yBP. Those regional diversity of water resources might be related to the distribution of permafrost. The recent global warming has provided the quick melting of permafrost, and has caused the increasing of water level. Area of Khudel Peat Land was far from the distribution of permafrost. For the survey at Altai Mountain, western Mongolia, we collaborate German researchers, because recent 10 years, there were many field expeditions by German Team at the lakes at Altai Mountain Area. Therefore, we arranged the international research team by Kyushu University, Ritsumeikan University, Tottori University, Institute of Geography and Geoecology, Mongolian Academy of Sciences and Gottingen University. We used the samples by our field surveys and the samples by the German previous surveys. We found the two times of high water stages after 4500 years BP using diatom analysis of the cores. Our preliminary analysis presumed that the dry period occurred during 2340-1050 years BP. After 700 years BP the lake level has increased again. Recently the melting water from the permafrost has offered huge water resource into the lake.	

一般研究 8 General Research 8	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	ムギ類における誘導性テルペノイドによる生体防御 Defense mechanisms by inducible terpenoids in barley and wheat	
共同研究要旨 Summary of	Plants respond to biological and environmental stresses by changing secondary metabolism. Howev-	

Joint Research	er, in barley and wheat, stress-inducible metabolites have not been identified. Thus, we tried to find the metabolic pathways that are activated by the stresses. First, we inoculated *Bipolaris sorokiniana*, the causal agent of black spot of grasses, to barley leaves, and analyzed the metabolic changes. LC-MS analysis indicated the accumulation of compounds **1**-**6**. These compounds were identified to be lyso-galactolipids and lyso-phospholipids, suggesting that barley leaves respond to the pathogen attack by activation of lipase and generate lyso-lipids. This is the first finding of the stress-induced accumulation of lyso-lipids in plants. Second, we analyzed the metabolic changes in the wheat leaves infected by *B. sorokiniana*. In the leaves, two compounds accumulated at high concentrations. These compounds were undescribed amides, and were referred to as triticamides A and B. Because these compounds showed antimicrobial activity, they were considered to function as phytoalexin in wheat. Third, we investigated the inducible metabolites in barley root. The root infected by *Fusarium culmorum* accumulated new compound triticamide C as well as triticamides A and B. In addition, we analyzed the biosynthesis of triticamides, and showed that HvTHT7 and HvTHT8 encode the biosynthetic enzymes for triticamides by molecular cloning and characterization of the enzyme encoded by the genes. These findings indicated that barley and wheat respond to biological stresses by dynamic changes in the lipid and phenolic metabolisms.

一般研究 9 General Research 9		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	植物の飛砂耐性におけるクチクラの役割 Role of cuticle in plant tolerance to injury from wind-blown sand		
共同研究要旨 Summary of Joint Research	In this research, we investigated the physical structure and chemical composition of cuticle of coastal plants and inland plants growing in Tottori sand dune to discuss the contribution of those properties to the tolerance to injury from wind-blown sand. Five leaves were sampled for each of four inland plant species and 11 coastal plant species in sand dune and experimental garden in Arid Land Research Center. Sampled leaves were sliced into a thin section subsequent to the resin embedding, and then subjected to the fluorescence microscopy. Cuticle thickness was measured by using an image analysis software. After microscopy, epicuticular waxes were extracted from those leaves by dichloromethane to analyze the amount and chemical composition of wax using gas chromatography. Leaf shape was different between species, and the thickness of cuticle also varied among species. Coastal plants had thicker cuticle than inland plants, though the difference was not statistically significant. Thicker cuticle has been shown to contribute to the physical strength of leaves, implying that the leaves of coastal plants have higher physical strength and thereby have higher tolerance to the injury from wind-blown sand. The accumulation of epicuticular wax was largely different among species, and its chemical composition was also varied among species. Similarity in the chemical composition of wax was analyzed by principal component analysis, but any clear difference between coastal plants and inland plants was not detected. In total, this study showed some possibilities that cuticle is contributing to the plant tolerance to the injury from wind-blown dust, though the contribution could not be demonstrated clearly. It is necessary to study on more species to clearly demonstrate the difference in thickness and chemical composition of cuticle between coastal and inland plants. In addition, it is expected to demonstrate the contribution of cuticle to the physical tolerance to the injury from wind-blown dust by the direct observation of the physical injury by microscopy.		

一般研究 10 General Research 10		対応教員 Corresponding Staff	黒崎　泰典 Kurosaki, Yasunori
研究代表者 Principal Researcher	牧　輝弥（金沢大学理工研究域） Maki, Teruya (College of Science and Engineering, Kanazawa University)		

研究課題 Research Subject	砂漠上空に舞い上がるバイオエアロゾルの発生メカニズムとその長距離輸送の解明 Long-range transport of bioaerosols originated from Asian desert areas
共同研究要旨 Summary of Joint Research	Asian dust events caused in desert areas carry airborne microorganisms, which would influence climate changes, ecosystem dynamics and human health in downwind area of East Asia. However, the vertical transport of airborne microorganisms over desert areas has not understood in detail. In 2016 and 2018, we have collected aerosols at high altitudes of hundreds meter over the Gobi Deserts. High-throughput sequencing targeting 16S rRNA genes (bacterial marker) and internal transcribed spacer regions (fungal marker) showed that many kinds of airborne bacteria and fungi were distributed vertically overt the sampling sites. Furthermore, Fluorescence in situ hybridization targeting *Bacillus* species revealed that several the cells of *Bacillus* species occupied from 20% to 80% of all microbial cells over Gobi Deserts during dust events. It is suggested that the spore-forming bacteria such as *Bacillus* species have high possibility to be transported from desert area for long distance. In addition, bioaerosol samples have been collected at Asian-dust source regions (Gobi Desert; Tsogt-Ovoo and Dalanzadgad) and arrival regions (Noto Peninsula, Mt. Tateyama) during the Asian dust events from 2015 and 2019. Actinobacteria increased in relative abundance at the continental sites during dust events, while marine bacterial signatures (mainly Alphaproteobacteria) were more prevalent in Japanese sites after dust events dissipated upon Japanese Sea. Overall, dust events increased the richness of airborne bacteria communities originating from inland desert and other area during early spring and are associated with more variations in airborne bacteria in the island site than the continental-peninsula site. Airborne desert dust is likely a significant transport vehicle for bacteria. The transit of air masses over continental and marine surfaces is selective for some taxa which can be transported to distant sinks with potential impacts toward ecosystems and public health.

一般研究 11 General Research 11	対応教員 Corresponding Staff	藤巻　晴行 Fujimaki, Haruyuki
研究代表者 Principal Researcher	篠田　雅人（名古屋大学環境学研究科） Shinoda, Masato (Graduate School of Environmental Studies, Nagoya University)	
研究課題 Research Subject	地中海沿岸地域における干ばつが農業・生態系に及ぼす影響 Drought impacts on agriculture and ecosystems around the Mediterranean Sea	
共同研究要旨 Summary of Joint Research	Drought characteristics and its impacts on vegetation activity and agriculture production were assessed in four zones of the Mediterranean; temperate woodland, temperate steppe, arid steppe and arid desert. We used monthly meteorological (Standardized Precipitation Index, SPI, and Standardized Precipitation Evapotranspiration Index, SPEI), and soil moisture (Palmer Drought Severity Index, PDSI) drought indices and compared them with the weekly Normalized Difference Vegetation Index (NDVI) and yearly crop yield data for wheat, maize, rice and soybean during the growing seasons. Short-term meteorological droughts were frequent, triggering soil moisture droughts that were more persistent. When comparing the indices, SPEI was identified as the best indicator of vegetation droughts for the woodland, SPI for the steppe (temperate and arid), while PDSI was the best for the desert. To further investigate the vegetation mechanism, two composites for years with high and low $NDVI_{max}$ were selected. We found no significant difference between low and high $NDVI_{max}$ years in terms of NDVI during the early growth period (Dec-Mar for the temperate zones, and Sep-Dec for the arid zones). However, a more significant difference was observed for the following months and maintained during spring reflecting a difference in zone-specific index between the two composites with a lag of 4 months in the woodland and desert, and 2 to 3 months in the steppe. Moreover, preliminary results of synoptic circulation patterns during the growing seasons for the two composites for each zone indicated that the wet pattern is caused by central depression, while the dry pattern is due to anticyclonic circulation. These patterns are more pronounced over the temperate zones. On the other hand, the meteorological drought indices proved to be better in assessing the agriculture response in the temperate climate zones and the arid desert, while the soil moisture drought indices showed better results in the arid steppe.	

一般研究 12 General Research 12		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	落葉広葉樹における水分欠乏による耐乾性と耐凍性の類似性の検証 Verification of the affinity of drought and/ or freezing tolerances under water deficit in deciduous broad-leaved trees		
共同研究要旨 Summary of Joint Research	Trees in cool-temperate and subarctic arid regions are sometimes exposed to summer-drought and winter-freezing conditions. Such exposure requests them to obtain both highly drought- and freeze-tolerant abilities. If a tree might exploit the trait of drought tolerance, which is the response to water deficit, to the freeze-induced decline of liquid water in tissues and/or organs, this property should become a powerful survival strategy. To verify the hypothetical probability, we analyzed the seasonality of internal heat distribution corresponding to the pattern of sap flow in *Zelkova serrata* (Thunb.) Makino, a deciduous broad-leaved tree in cool-temperate region. Granier-type sap flow probes and additional two reference probes were installed in a trunk vertically with 10 cm interval. Twenty-five T-type thermocouples (TC) were also installed in three columns (7 TC in the center column, in which Granier probes were included, and 9 TC both in the right and left columns). Thermal transition in the trunk was measured in the period from October 2016 to February 2018 with two-second interval, and their seasonal patterns were analyzed comparatively. General sap flow patterns were detected during October to mid-November 2016 and early-May to mid-November 2017. In these periods, upward heat convections were also observed, which corresponded to sap flow. Especially when sap flows were active (October 2016, and May to July 2017), internal trunk temperatures in the left column and just above the Granier-heater probe declined about 2 degree C. In March to April 2017, slight temperature decrease was detected at the upper sites of the left column, which suggest some morphological and/or physiological pre-events of leaf flush such as vessel formation and water movement. Similar temperature declines were observed during December 2017 to February 2018, which might correspond to the response of tree to winter freezing.		

一般研究 13 General Research 13		対応教員 Corresponding Staff	黒崎　泰典 Kurosaki, Yasunori
研究代表者 Principal Researcher	加納 靖之（東京大学地震研究所） Kano, Yasuyuki (Earthquake Research Institute, The University of Tokyo)		
研究課題 Research Subject	史料の収集・翻刻・解析による過去の黄砂イベントの復元 Reconstruction of Asian Dust Event Based on Historical Documents		
共同研究要旨 Summary of Joint Research	Online database for historical Asian dust event based on Nihon Kishou Shiryou (Collection of materials for the history of Japanese weather events) has been developed. Nihon Kishou Shiryou is the compilation of articles describing meteorological phenomena such as Storm, flood, thunder, tornado, drought, long rain, snow, hail, frost, anomalous cloud, rainbow, fog, aurora, season, drop of anomalous material. Articles are quoted from historical documents with date of the events in Japanese and western calendar, and reference information. Possible Asian dust events are extracted from “Inpu-nenpyo” and “Gatsudo-kenmonsyu.” “Inpu-nenpyo” is historical record of the Tottori domain. There are plenty of descriptions which possibly represent Asian dust event. “Gatsudo-kenmonsyu” is a journal written in Kyoto. The situation of dusty air for about one month are recorded. The situations can be examined in detail by careful reading of weather records before, during, and after the events.		

一般研究 14 General Research 14		対応教員 Corresponding Staff	安　萍 An, Ping
研究代表者 Principal Researcher	清水　英幸（国立環境研究所地域環境研究センター） Shimizu, Hideyuki (Center for Regional Environmental Research, National Institute for Environmental Studies (NIES))		
研究課題 Research Subject	オゾン－水ストレス複合環境が半乾燥灌木種の生長と生理生態に及ぼす影響の解析 Impact analysis of ozone-water combined stress on the growth and eco-physiology of semi-arid shrub species		

共同研究要旨 Summary of Joint Research	Recently, some simulation suggested that relatively high concentrations of ozone have spread to semi-arid grasslands in Northeast Asia (Yamaji et al, 2008, J. Geophys. Res., 113), although there have been very few studies for the ozone effects on plants growing in those areas (Shimizu et al, 2005, Phyton, 45). Therefore, impacts of ozone on semi-arid grasslands of Northeast China have not yet been assessed. In the present study, we focused on the major shrub species growing in semi-arid grasslands and examined the mechanism of the combined effects of ozone and water stresses on the dry weight growth from an eco-physiological viewpoint. Seedlings of shrub species *Caragana korshinskii* were transplanted in pots (100mm × 40cm^2) packed with artificial soils (similar particle size of Mu Us Sandy Land), and were grown in a greenhouse. Thereafter seedlings were moved into plant growth cabinets controlled to a semi-arid environment: 14 hours/10 hours (light/dark), approximately 1,500 μmol $m^{-2}s^{-1}$ in photon flux density (light), 25/15°C in temperature (light/dark), 50/60% in relative humidity (light/dark). A four-week growth experiment was conducted using 1 or 2 cabinets. Exp.1: Water stress experiment was carried out with irrigation every 2-3 days, corresponding to 30, 60, 90 (control) and 120 mm/month. The average water potential is -15.2, -6.7, -3.1, -2.6 kPa, respectively. Exp.2: Plants were exposed to an average of 50 ppb ozone (20-100 ppb) and compared with non-exposed plants. Exp.3: A combined treatment of irrigation (4 levels as Exp.1) and ozone exposure (2 levels as Exp.2) was performed. *C. korshinskii* grew better in more precipitated condition as 120mm than 90mm/month. Water stress suppressed a dry matter production of *C. korshinskii* remarkably, while assimilate partitioning was hardly affected. Just ozone exposure did not affect the dry weight growth of *C. korshinskii*, with relatively slight decrease in root. From the combined experiment, leaf senescence was accelerated by water stress, especially with 30mm/month with/without ozone exposure, whereas it was accelerated in only ozone exposed plants with 60mm/month treatment. The leaf area decreased with a decrease in irrigation level, while it was hardly affected with ozone. Comparing the dry weight of whole plant, the plants without ozone showed a remarkable decrease in dry weight only with the 30mm/month treatment, whereas the ozone-exposed plants was affected with the 60mm in addition with the 30mm/month treatments. *C. korshinskii* might be affected with ozone exposure in more water stressed environment. For the stable semi-arid grasslands, it is necessary to consider the long-term combined impacts of climate change and air pollution on some key shrub and grass species.

一般研究 15 General Research 15	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	乾燥地作物の葉面ワックス層の構築メカニズムと環境ストレス耐性との関連 Developmental mechanism of leaf wax layer in arid land crops: Evaluation on the relevance to the environmental stress resistance	
共同研究要旨 Summary of Joint Research	Fortification of wax deposition in the leaf cuticle layer is considered as one of the adaptative mechanism in plants under adverse environmental condition, but physiological significance and molecular mechanism of cuticle layer development have not been fully investigated in arid land plants. In this study, relationships between cuticle wax fortification and excess light reflection are examined using representative arid land plants, including a set of common wheat NIL lines differing cuticle wax levels and drought-tolerant biofuel crop Jatropha. Light reflection assay showed that several wheat NIL lines defective in the wax deposition had lower efficiency for reflecting light, suggesting that cuticle wax layer may contribute to the avoidance of excess light absorption in the high light condition. In some NIL lines, wax composition was altered by which very long chain fatty acid was specifically deficient. In other experiments, leaf wax deposition was significantly enhanced in Jatropha grown in mineral-rich and/or biochar-amended soils, which were associated with translocation and deposition of specific mineral ions such as nickel in the leaves. These observations suggested that responses of cuticle layers to the environmental stimuli in arid land plants included not only changes in the amount and composition of wax components, but also the metabolism and transport of other cellular components such as mineral ions. These results also suggested that cuticle wax development is associated with an avoidance mechanism of plants under excess light conditions in the arid land.	

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 Technology)		
研究課題 Research Subject	複数の環境ストレス耐性を誘導するオオハマニンニク染色体の起源と進化 Origin and evolution of *Leymus racemosus* inducing multiple abiotic stress tolerance		
共同研究要旨 Summary of Joint Research	Leymus racemosus is a wild plant species which has strong adaptability to various environments. Transcriptome analysis in Leymous racemosus was done under multiple environmental conditions using the joint research collaboration with Tokyo University of Agriculture Bioresources Genome Analysis Center. Additionally, wheat lines (Chinease spring) with of A, E, F, H, I, J, K, L, and N chromosomes were generated by Prof. Tsujimoto (Tottori University). After performing transcriptome analysis of these additional chromosome lines, we determined transcribed sequences derived from each chromosome. In these previous studies, gene sequences derived from three pairs of homoeologous chromosomes were obtained. As a result, about 6.6-9.4% of the genes expressed in both chromosomes in the set of homoeologous genes can be identified between the homologous chromosomes in Leymus racemosus. This was significantly lower than the proportion of homologous genes expressed in the genomes of all the wheat A, B, and D genomes (46.8-49.4%). Next, the distribution of amino acid change rates was also examined for wheat and garlic. As a result, it was revealed that the amino acid change rate of Leymous racemosus was significantly higher than that of wheat. This means that the selection pressure for retaining the gene relating to t Leymous racemosus gene is weaker than the selection pressure retaining the gene relating to the wheat gene.		

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	岩永　史子（鳥取大学農学部） Iwanaga, Fumiko (Faculty of Agriculture, Tottori University)		
研究課題 Research Subject	中国クブチ砂漠の埋砂・退砂環境における緑化樹種の形態的適応と同化産物配分に関する研究 Studies on morphological adaptability and carbon allocation of reforestation trees under sans burial/ exposure condition		
共同研究要旨 Summary of Joint Research	*Populus* trees are important species as reforestation and sand dune fixation trees in dry and semi-dry areas in China. *P. simonii* and *P. alba* are native species to Northwestern China and have high ability to thrive sand burial condition. Our study demonstrated the growth characteristics against rapid burial stress by nursery experiment and field survey. In the nursery experiment, all above ground shoots of *P. alba* saplings were buried in sandy soil as burial treatment. To inhibit shoot elongation, inhibiting agent of gibberellin biosynthesis (Uniconazol-P) in combination with burial treatment was applied to saplings. Unburied saplings were grown and watered 2-3 days as Control treatment. For field grown *P. simonii,* we carried out survey on root coppice and tree height around sand dune and discussed the relationships between topographic conditions. We settled research plots around moving sand dune: a) top of moving sand dune; b) mid-slope of sand dune, c) flat area around sand dune. Variable selection was made by generalized linear regression model using surface topographic index (slope, surface relief, elevation), sprouting shoot size and number of occurrences generated by the survey as dependent variables. Tree height of *P. simonii* around sand dunes was higher in mid-slope than those in flat or top sites of sand dunes. The GLM results suggested that the sprout size and sprouting occurrence were influenced by surface topography, especially surface relief. In the nursery experiment, saplings of burial treatment showed highest shoot growth and survival rate among treatments. Such shoot growth increment would be advantageous to survive low light and oxygen condition caused by sand burial.		

一般研究 18 General Research 18		対応教員 Corresponding Staff	小林　伸行 Kobayashi, Nobuyuki
研究代表者 Principal Researcher	北川　博史（岡山大学社会文化科学研究科） Kitagawa, Hirofumi (Graduate School of Humanities and Social Sciences, Okayama University)		
研究課題 Research Subject	乾燥地における廃鉱の商品化と地域再生 Local Reproduction and Commodification of Abandoned Mines in Drylands		
共同研究要旨 Summary of Joint Research	Economic development in arid areas is often limited by the mining industry because of the harshness of their natural environment. Even now, in the arid regions of developing countries, mining development is rapidly progressed in many areas along with the rise in demand for mineral resources. However, if the resources are exhausted, such mines will be abandoned. In the mine settlements and areas located in the abandoned mines and their surroundings, there are many cases where villages and areas themselves are disposed of after the loss of basic industries. In the case of arid lands, it is rare for regions to be regenerated, as the key industries to be replaced are limited, and there is a high possibility that the villages will be disposed of. On the other hand, in dry areas such as Australia and the United States, although there are not many mine settlements and areas abandoned along with waste mines, some of the mining communities are undergoing sustainable development after the mine has been refurbished. If the processes and mechanisms of regional regeneration in the waste mine settlement of such arid land are clarified, it is possible to develop mining resources for mines and mine settlements and areas that are being developed in a certain way, in a dry place in developing countries, we can provide one hint on advancing sustainable economic development. For that reason, this year we selected Western Australia as an advanced case area, studied the regional trends, and tried collecting data. As a result, in order to contribute to regional regeneration and sustainable development in arid regions, it is necessary to engage more stakeholders, to have capital accumulation for economic development and to make the network among settlements.		

一般研究 19 General Research 19		対応教員 Corresponding Staff	安　萍 An, Ping
研究代表者 Principal Researcher	松浦　朝奈（東海大学農学部） Matsuura, Asana (School of Agriculture, Tokai University)		
研究課題 Research Subject	エチオピアにおける世界最小の雑穀テフの栽培と環境ストレス下の生産性 Cultivation of teff in Ethiopia and productivity of teff under stress environments		
共同研究要旨 Summary of Joint Research	Salinity and waterlogging simultaneously occur due to poor physical properties of the sodic soil in salt affected soils in the world. In order to achieve stable food production under such conditions, it is necessary to introduce and breed plants that are resistant to combined stress of low oxygen and high salt concentrations. Millet often grows vigorously under conditions where the main crops do not grow vigorously, however, there is few reports of the responses to low oxygen and high salinity. From the results of SSI of PGR in the combined stress (NaH) treatment, the combined stress tolerance was found to be *Eragrostis tef* ≥ *Eleusine coracana* > *Echinochloa utilis* = *Setaria italica*. It was considered that the combined stress tolerance is mainly due to the difference in salt tolerance (Fig. 1). Salt tolerance was analysed as water stress and ion stress. As an index of water stress, the leaf water potential was measured, and did not agree with the interspecific difference between PGR of NaH. Therefore, the combined stress tolerance was considered to be mainly based on ion stress. The leaf Na content of the NaH treatment was consistent with the interspecies differences in PGR of NaH treatment. The relationship between PGR and Na content in leaves revealed a significant regression curve at the 1% level. There were no interspecific differences in Na content both of the above-ground part also the whole plant in NaH treatment. These results suggest that the tolerance of hypoxia and salt complex stress in four millet species is determined by salt tolerance rather than hypoxia tolerance, and that sodium accumulation in leaves is mainly involved.		

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	西原　英治（鳥取大学農学部） Nishihara, Eiji (Faculty of Agriculture, Tottori University)		
研究課題 Research Subject	乾燥地に生育する薬用植物ウラルカンゾウの主根に含まれるグリチルリチン蓄積の促進方法 Promoting method of glycyrrhizin accumulation induced in taproot of licorice (*Glycyrrhiza uralensis* Fisher) growing on arid land		
共同研究要旨 Summary of Joint Research	The preference for the different ratio of NH4+-N and NO3--N of licorice was investigated. And the damage of licorice root tissue which was cause by NH4+-N was evaluated from the amount of malondialdehyde (MDA) that is representative lipid peroxidation. The experiment was carried out as hydroponics, and the medium was adjusted into 5 ratios. The treatments were Urea 100% (Urea-N), NH4+-N: NO3--N =1:0(NH4+-N), NH4+-N: NO3--N =1:1, NH4+-N: NO3--N =0:1(NO3--N) and NH4+-N: NO3--N =1:9(Control). The plant hight was not affected by the different ratio of NH4+-N and NO3--N. There was no difference between treatments. The SPAD value and the fresh weight of whole plant also had no significant difference but that was highest in Control, and the SPAD value was decreased to 61% (Urea-N), 73% (NH4+-N), 85% (NH4+-N: NO3--N =1:1), 68% (NO3--N) in comparison with Control. The fresh weight of whole plant decreased to 40% (Urea-N), 58% (NH4+-N), 86% (NH4+-N: NO3--N =1:1), 58% (NO3--N) in comparison with Control. The amount of MDA had a tendency to increase when the amount of NH4+-N is higher. This result suggests that NH4+-N caused the damage to root tissue. The MDA content was lowest in Urea-N treatment. This result was considered the speed to convert urea to ammonia was slow because the medium of hydroponics was changed once per week and the temperature was relatively low (the average air temperature was 19.1°C) during cultivation of experiment. Thus, the fresh weight of licorice is also low in Urea-N treatment. Consequently, licorice has high preference for NO3--N over NH4+-N. High concentration of NH4+-N might cause the damage to root tissue, and it was suggested that the ratio of NH4+-N: NO3--N = 1:9 can promote the growth of licorice.		

一般研究 21 General Research 21		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	物理センサ群を用いた土壌・植物・大気連続系における物質移動の解明 Clarification of mass transfer in Soil-Plant-Atmosphere-Continuum using physical sensors		
共同研究要旨 Summary of Joint Research	The objective of this study was to clarify water use characteristics of trees and mechanism of water movement/storage in SPAC (Soil-Plant-Atmosphere-Continuum) through non-distractive monitoring of parameters on water conditions of trees. A field experiment was conducted to monitor stem water potential, water content, electrical conductivity and sap flow using several physical sensors. Three test trees of Japanese pear (*Pyrus pyrifolia*)(Hosui, Gold Nijisseiki, and Oushuu) in Ootsuka FSC, Tottori university were used in this study. An evergreen tree (*Quercus myrsinifolia*) planted in a large pot was also used for quantitative analysis. Stem water potential was measured using a stem psychrometer (PSY-1). Stem water content and electrical conductivity were measured by capacitance sensors (GS3). Sap flow was measured by a sap flow sensor (SFM-1). Monitoring of sol water content at different depths using capacitance sensors and monitoring of metrological conditions were also conducted around the tree. The monitoring results from Japanese pear trees clarified that characteristic daily and seasonal variations in the sap flow, stem water potential and stem water content. The PSY-1 monitored decrease in the stem potential at night suggesting that stem psychrometer has potential to monitor translocation of photosynthetic products. The results from *Quercus myrsinifolia* showed that stem water was consumed at upper part of the tree at early morning. The stem water at upper part recovered after rainfall events by absorbing rainwater not from the roots but from the bark.		

一般研究 22 General Research 22	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 for Plant Science and Resources, Okayama University)	
研究課題 Research Subject	コムギの長葉毛が乾燥耐性に及ぼす影響の遺伝生理学的解析 Genetic and physiological effects of leaf hairs on drought tolerance in wheat	
共同研究要旨 Summary of Joint Research	Chinese wheat landrace, Hong-Mang-Mai, has long pubescence on the leaf blades and is well adapted to the drought environment in Loss platau. Our previous study revealed that this hairy leaf characteristic is controlled by a single dominant gene, *Hl2*, which is located on the short arm of chromosome arm 7BS. To elucidate genetic and physiological mechanisms underlying the drought resistance of Hong-Mang-Mai wheat, we employed the recurrent backcross method and developed two pairs of isogenic lines differing in the presence or absence of the *Hl2* gene under the uniform genetic backgrounds of Chinese Spring and Hong-Mang-Mai, respectively. In the first year (2018/2019), we multiplied and harvested BC8F5 generation seeds of NILs both in Kurashiki and Tottori. In Kurashiki, molecular mapping of the *Hl2* gene was initiated using public SSR markers. So far, we tested 20 markers that were reported to reside on the wheat chromosome arm 7BS, and four of them showed polymorphism between Chinese Spring and Hong-Mang-Mai. In parallel, we are analyzing a barley artificial mutant with hairy peduncle. We revealed that the barley hairy peduncle trait is controlled by a dominant gene on the 7HS chromosome arm. We speculate that the barley hairy peduncle gene should be connected with the wheat *Hl2* gene, in view of their similar chromosomal locations.	

一般研究 23 General Research 23	対応教員 Corresponding Staff	石井　孝佳 Ishii, Takayoshi
研究代表者 Principal Researcher	長岐　清孝（岡山大学資源植物科学研究所） Nagaki, Kiyotaka (Institute of Plant Science and Resources, Okayama University)	
研究課題 Research Subject	乾燥、高温ストレス耐性作物の創生に向けて- CRISPR/Cas9 による染色体イメージング法の開発 Creating new crops for dry and heat tolerant: Developments of imaging methods for alien chromosomes using CRISPR/Cas9 system	
共同研究要旨 Summary of Joint Research	(1) Acquisition of information on repetitive sequences of species that can be parents of crosses suitable for arid and high temperature regions Genomic DNA sequence information of bread wheat (*Triticum aestivum*), *Aegilops tauschii*, *Triticum urartu*, maize (*Zea mays*), and pearl millet (*Pennisetum glaucum*) was obtained by a next-generation sequencer, and they were analyzed and classified by a repetitive sequence analysis program (RepeatExplorer). In the RepeatExplorer analysis, bread wheat sequences formed eight clusters of tandem repeat DNA sequences, two clusters of LTR-type retrotransposons, and two clusters of ribosomal DNA (rDNA). Many of these were known repetitive DNA sequences, but in bread wheat, where many repetitive DNA sequences have been analyzed, this analysis has revealed novel repetitive DNA sequences that have not been defined previously. Maize has also been used as a target for repeated DNA sequence analysis for many years as the wheat, but this analysis has identified four undefined clusters containing LTR-type retrotransposons in the maize sequences. Since the pearl millet repetitive DNA sequence has not been analyzed so far, one of the nine clusters formed in this analysis has one centromeric tandem repeat DNA sequence and two rDNA clusters. The other six were new repetitive DNA sequences. (2) Design of crRNA based on repetitive sequence information and genome labeling by RGEN-ISL Based on the repetitive DNA sequence information obtained by the above analysis, crRNAs to be used for RGEN-ISL were designed and synthesized. The chromosomal localization of these target sequences was investigated by RGEN-ISL using the synthesized crRNA.	

一般研究 24 General Research 24		対応教員 Corresponding Staff	黒崎　泰典 Kurosaki, Yasunori
研究代表者 Principal Researcher	関山　剛（気象庁気象研究所全球大気海洋研究部） Sekiyama, Tsuyoshi (Department of Atmosphere, Ocean and Earth System Modeling Research, Meteorological Research Institute, Japan Meteorological Agency)		
研究課題 Research Subject	陸面状態の影響を強く受けた黄砂発生量の数値モデルシミュレーションと予測 Numerical model simulation and prediction for Asian Dust emission strongly influenced by land surface conditions		
共同研究要旨 Summary of Joint Research	A box-model (i.e., 0-dimensional model of Shao's dust emission scheme) was performed to represent the relationship between the surface wind speeds and dust emissions measured at seven observatories in the northern Gobi Desert. The model yielded a large discrepancy in sand saltation compared with observations when using standard model parameters. Hence, we installed the parameterization of coverage and shear stress partitioning effects by stones on sand saltation into the box-model, and estimated sand saltation with the in-situ measured values of stone coverage at the seven observatories. Consequently, the estimation was highly consistent with the measured dust emissions. This indicates that the stone effects have a large impact on sand saltation and dust emission, and therefore, the parameterization of the stone effects is potentially promising to significantly improve dust modeling. We investigated a horizontal resolution dependence of regional weather models on wind velocity accuracy. The finer resolution of weather models resulted in the higher model performance, which was never saturated even if the resolution was increased by more than 20 times from a common setting of regional weather models (approx. 5 km resolution), over complex mountainous terrains. In contrast, we could not find any remarkable horizontal resolution dependency over flatlands (e.g., plain on a 100 km × 100 km scale) at resolutions of less than 10 km. The findings are beneficial for preferable settings of the regional weather model horizontal resolution to simulate the whole Gobi Desert. The time series of dust concentration on the Sea of Japan side simulated by the Meteorological Research Institute (MRI) global aerosol numerical model was compared with the prevalence of asthma epidemiologically estimated in Tottori Prefecture, of which result proved the correlation of them.		

一般研究 25 General Research 25		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	通水特性が制約する黄土高原のニセアカシア成長 Plant hydraulics limits the growth of *Robinia pseudoacacia* in Loesse plateau		
共同研究要旨 Summary of Joint Research	We planned monitoring of plant- to stand-water dynamics in a *Robinia pseudoacacia* plantation stand in Loess plateau, under control and drought treatments. Due to delay in the establishment, however, we aimed to eliminate the uncertainty associated with the manufacturing and the performance of the new sapflow sensor, heat ratio method sensors. We installed HRM sensors on *R. pseudoacacia* trees in Ito Campus, Kyushu University and monitored the sapflow under less evaporative conditions to examine the ability to capture minute saoflow changes in response to changing environments. Costs and time required for manufacturing each sensor was similar to those for widely used sensors (thermal dissipation type: TDP). Power use and the longevity of each sensor were by far better than those of TDP. Measured sapflow was strongly correlated with the changes in solar radiation and atmospheric vapor pressure deficit, which are the environmental forcing for transpiration from leaf surface. HRM sensors could capture nighttime sapflow, which can be only extrapolated by TDP, and found non-negligible amount of nighttime sapflow in *R. pseudoacacia* even during moist environments. Results suggested that HRM sensors are suitable for the sapflow monitoring in remote research sites in Loess plateau with even better outputs than those obtained by TDP sensors. Our system can be used in the monitoring next year and will allow us to immediately start monitoring as the study site is established and accessible next spring.		

一般研究 26 General Research 26		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ダストの発生源分布と長距離輸送過程の高精度化についての研究 Studies on improved estimation of emissions and long-range transport of dust using a global aerosol model		
共同研究要旨 Summary of Joint Research	Mineral dust has large impacts on the climate and human health. Dust is emitted from arid and semi-arid regions when wind friction velocity u_* is greater than its threshold value u_{*t}. There are many global climate modeling studies on mineral dust, but they still have large uncertainties in the estimation of u_{*t} and dust emissions. The objective of this study is to evaluate and improve the estimation of u_{*t} and dust emissions in our global aerosol model, CAM-ATRAS (Matsui, 2017; Matsui and Mahowald, 2017), by using u_{*t} calculated based on MODIS satellite observations (Kimura and Shinoda, 2010). We compared u_{*t} between our model simulations and satellite estimates. Compared with the satellite estimates (u_{*t} around 0.4 m s^{-1}), model simulations underestimated u_{*t} by 0.1~0.2 m s^{-1} over the Gobi and Taklimakan Desert. Due to this underestimation of u_{*t}, model simulations overestimated the frequency of dust emissions over the East Asian region when we compared with the surface synoptic observations (SYNOP) data. Since the underestimation of u_{*t} and the overestimation of dust emission frequency may lead to errors in the simulations of long-range transport of dust and its radiative and climate impacts, we will improve the treatment of u_{*t} calculations in our model.		

一般研究 27 General Research 27		対応教員 Corresponding Staff	木村　玲二 Kimura, Reiji
研究代表者 Principal Researcher	松島　大（千葉工業大学創造工学部都市環境工学科） Matsushima, Dai (Department of Civil and Environmental Engineering, Chiba Institute of Technology)		
研究課題 Research Subject	極乾燥砂漠に存在するオアシス及びその周囲における表層土壌水分量分布の推定 Estimating spatial distribution of the surface soil moisture over an oasis and its surrounding area located in a desert under an extreme dry condition		
共同研究要旨 Summary of Joint Research	This study aims estimating daily changes of spatial distribution of surface soil moisture conditions using a surface heat budget model over the Dakhla Oases in Egypt, where the potential ground water resources are concerned. The target area is approximately 100^2 km^2 outlined by 25-26°N, 28.5-29.5°E. Thermal inertia, which is almost proportional to soil moisture included in sandy soil, is used as a proxy variable of soil moisture. Thermal inertia is retrieved from the heat budget model with the spatial resolution being 2 km when the spatial resolution of satellite land-surface temperature is 1 km (MODIS), or 500 m when 250 m (SGLI). The NDVI data of SGLI are also used for verification of the thermal inertia estimations. Comparing daily thermal inertia estimates over the oases and the surrounding desert reveals periodic changes in thermal inertia over the oases with the periods of a few days to 20 days, which may correspond to periodic irrigations that is reported as it is conducted approximately every 12 days. Another result showing the irrigation was conducted in the oases is the increase in thermal inertia on 23 Oct 2018 compared to those on the previous day. In particular, it is found that the thermal inertia positively correlates with the NDVI well when the SGLI land-surface temperature is used. By contrast, unreasonable estimates of thermal inertia due to topography are found. The future study has to show the details of the water-use over the oases that should be validated using observational data of soil moisture and the model estimation of evapotranspiration, and to investigate how the unreasonable estimates are retrieved.		

一般研究 28 General Research 28		対応教員 Corresponding Staff	小林　伸行 Kobayashi, Nobuyuki
研究代表者 Principal Researcher	一戸　俊義（島根大学生物資源科学部） Ichinohe, Toshiyoshi (Faculty of Life and Environmental Science, Shimane University)		
研究課題 Research	GPS と加速度データロガーを用いたエチオピア放牧牛の代謝エネルギー要求量の推定 Estimation of metabolizable energy requirement for grazing dairy cattle in Ethiopia using GPS and		

Subject	acceleration-data logger
共同研究要旨 Summary of Joint Research	We estimated metabolizable energy sufficiency of Fogera lactating cow grazed on natural grassland in rainy season by assessing energy expenditure in daytime grazing. Study was carried out at Andasa Livestock Research Center, Amhara Regional Agricultural Research Institute, Bahir Dar, Ethiopia in September 2019. Four non pregnant lactating Fogera cows, equipped GPS and accelerometer in their back of heads, were used and grazed on plane experimental grazing land as herd comprised of 91 head of cows for 08.00-16.00 daily. Animals were offered supplemental concentrate (1.7 kg/d/head) according to conventional feeding regimen at Andasa Livestock Research Center and milked twice a day. Samples of grazed forage, concentrate and rectum feces were obtained. Nutritive value of the feeds was determined by the conventional *in vitro* gas production technique and chemical composition analysis and organic matter digestibility was determined by an exponential equation using fecal crude protein concentration. The net energy requirement of the animals and the energy sufficiency were estimated by using equations listed in NRC (2001), animal BW, lactation performance and feed evaluation datum. Although the herbage mass was plenty, the nutritive value of forages grown in the experimental graze land was poor. The organic matter digestibility and forage intake in grassland was estimated as 58% and 4.7 kg dry matter per day, respectively. The metabolizable energy sufficiency for the lactating cows was estimated to be 104% of the requirement by NRC (2001) recommendation. It was suggested that the USA feeding standard (NRC) can be applicable to calculate the energy requirements and establish feeding regimens of Ethiopian indigenous local cow in confined feeding. Further study should be needed whether NRC would reveal lactating cows energy requirement or some corrections to NRC in dry season (hot climate).

一般研究 29 General Research 29	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	乾燥ストレス条件がソルガム穀粒中のミネラル含量に及ぼす影響 How does drought stress influence grain mineral contents in sorghum (*Sorghum bicolor*)?	
共同研究要旨 Summary of Joint Research	An alleviation of drought stress by silicon application is reported (Hattori et al., 2005). To reveal the effects of silicon application on mineral contents in sorghum (*Sorghum bicolor* cv. K8) grains, we cultivated the sorghum under drought stress conditions with or without silicon treatments. As a control, normal growth conditions were also applied. This study found that slight enhancement of shoot growth by silicon treatment was observed during vegetative growth stage, although no significant difference was found at the end of the growth stage. SPAD values were almost similar among the treatments, meaning that nutrient conditions were not affected by our drought stress conditions and silicon application. In addition, the stem diameter before harvesting demonstrated that the shape of the stem became closer to a perfect circle by the silicon treatment. Weight of 100 seeds did not show significant difference between + and – silicon treatment, although the drought stress treatment decreased the 100 seeds weight. Manganese contents in grains was significantly increased in drought stress treatment compared to control. Si treatment made slight inhibition of manganese increasing in drought stress treatment. These results suggested that manganese contents were sensitive to drought stress. Furthermore, iron contents were increased by silicon application under drought stress conditions, although the difference was not significant. Further study is necessary to reveal an effectiveness silicon concentration influencing the growth and mineral contents in sorghum grown under drought stress conditions.	

一般研究 30 General Research 30	対応教員 Corresponding Staff	安　萍 An, Ping
研究代表者 Principal Researcher	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	干ばつ環境下におけるコムギ収量安定のための代替ソースの同定 Identification of alternative source for wheat yield stability under drought	
共同研究要旨 Summary of	Field trial in a rainout shelter was conducted at Hokkaido University in 2019. Three bread wheat varieties (Cham6, SW15 and Haruyokoi) were cultivated under well-irrigated and restricted-irrigation	

Joint Research	conditions. After the ear emergence (during the ripening period), treatment to restrict ear photosynthesis was imposed by covering the entire ear with aluminum foil (shading ear treatment), and as control treatment, normal cultivation with non-shading ear was set. Their drought performances and canopy photosynthesis were evaluated during the cultivation period. The major results obtained were below. 1. No significant difference was detected on the grain yield between the well- and restricted irrigations (Fig. 1). This indicated that drought intensity was relatively mild in this trial. 2. A significant yield reduction was observed by shading ear treatment. There was a significant correlation between the canopy photosynthetic rate and yield during the ripening period, which indicated that the significant contribution of ear photosynthesis to canopy photosynthesis. 3. Higer degree of contribution of ear photosynthesis to canopy photosynthesis under drought condition was observed in two ICARDA varieties, SW15 and Cham6, but not in a Japanese variety, Haruyokoi. This indicated that the relative importance of ear photosynthesis as source organ could be increased if they were subjected to drought conditions. These results indicate the importance of ear photosynthesis for maintaining the drought yield was varied among the wheat genotypes.

一般研究 31 General Research 31		対応教員 Corresponding Staff	山中　典和 Yamanaka, Norikazu
研究代表者 Principal Researcher	三木　直子（岡山大学大学院環境生命科学研究科） Miki H. Naoko (Graduate School of Environmental and Life Science, Okayama University)		
研究課題 Research Subject	中国乾燥地域の匍匐性樹木 *Juniperus sabina* の被覆が生態系修復にもたらす効果 Effects of the covering of the prostrate shrub *Juniperus sabina* on ecosystem rehabilitation in arid region of China		
共同研究要旨 Summary of Joint Research	Degradation of ecosystems due to desertification has a significant impact on the natural environment and socioeconomics. Therefore, conservation of native species, prevention of desertification and rehabilitation of ecosystems by revegetation using native species are important. Species diversity affects the resistance of ecosystems to desertification, and species diversity is largely driven by interspecific effects. *Juniperus sabina* L. is a native prostrate shrub and a representative species for revegetation, in semiarid areas of China. *J. sabina* has a canopy with a high shoot density and has high environmental mitigation effects such as hydraulic redistribution and nutrient accumulation. It has also been pointed out that *J. sabina* may have a high inhibitory effect through a competitive effect on resources, but allelopathic effects of this species have not been clarified. Therefore, in this study, we evaluated the allelopathic effects of *J. sabina* and the effects of *J. sabina* coverage on the environmental conditions and plant community structure, in order to clarify the effects of *J. sabina* coverage on species diversity. *J. sabina* exhibited allelopathic inhibitory effects on certain but not all species, and the effect was not as high as in the other seven woody species. Different environmental conditions were formed inside and outside the *J. sabina* coverage, which resulted in different plant community structures. It was suggested that the interspecific effects of *J. sabina* may have contributed to the enhancement of plant species diversity in the region.		

一般研究 32 General Research 32		対応教員 Corresponding Staff	石井　孝佳 Ishii, Takayoshi
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	①乾燥地研究センターに赴きディスカッションを行うことにより、乾燥地における作物の生育阻害の一つに鉄欠乏があることを確認し、鉄欠乏耐性作物の作出が乾燥地耐性作物の開発につながる可能性を見出した。 ②ニコチアナミン排出型トランスポーターENA1 の機能解析を行った。プロモーターGUS 解析により、ENA1 は鉄欠乏の根で主に発現されることが示された。また、根と地上部を連結する茎葉の基部において ENA1 の発現が見られ、その発現は鉄欠乏により誘導された。ENA1 と GFP の融合タンパク質は、タマネギの表皮細胞とイネの根細胞のいずれにおいても、主に細胞膜に局在した。一部の蛍光は細胞質の顆粒状構造に局在した。ENA1 過剰発現イネ及び ENA1 発現抑制イネを作出して、これらのイネの表現型を観察した。発芽初期に、ENA1 過剰発現イ		

	ネの根は、非形質転換体と ENA1 発現抑制イネに比べて、顕著に短く、多数の根毛を形成した。この表現型は成長するとともに消失した。オリゴ DNA マイクロアレイ解析により、ENA1 発現抑制イネにおいて、非形質転換体に比べて発現の変動している遺伝子を抽出して解析を行った。ENA1 発現抑制イネでは、細胞内小胞輸送と根のプラスチドに関わる遺伝子群の発現が変動していた。また、鉄十分条件で生育した ENA1 発現抑制イネは鉄欠乏誘導性遺伝子の発現が誘導されており、鉄欠乏条件では鉄欠乏誘導性遺伝子の発現が非形質転換体に比べて減少していた。以上の事から、ENA1 は細胞膜と細胞内の画分の間を小胞輸送によりリサイクリングしていること、ENA1 の機能が鉄恒常性維持に関与している可能性が示唆された。

一般研究 33 General Research 33	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	1. Research method Intensive observation was carried out at Tsogt-Ovoo in the desert steppe of the Gobi Desert, Mongolia in May 2019. Figure 1 shows the location and installation status of the mobile observation equipment installed during the period. A total of four sites were installed from Sub Site 19A on the gravel-rich southern slope (Sub19A, hereafter Sub Site is referred to as “Sub”) to Sub19D at the bottom of the valley. In the spring of 2019, a lot of sand is distributed on the eastern side of the valley bottom (near Sub19D), and it is considered that the area was affected by the ephemeral lake formed in last summer. Sub14A, which was installed in 2014, was covered with short live vegetation, dead vegetation, and soil crust, and the ground surface condition was much different from Sub19D, which was only 2 km away. For the mobile observation, a small tower was temporally constructed using four steel poles, and a wind direction and anemometer, a saltation sand counter, and a particle counter (Sub19D only) were installed. Based on a forecast by IRIMHE that a dust event will occur on May 3, 2019, particle counters were set at Sub19D and Sub14A. 2. Results and discussion Figure 2 shows the temporal variations of dust concentration in Sub19D and Sub14A. The dust concentration in Sub19D was about 8 times higher than that in Sub14A. In addition, since the timing of increase of dust was almost the same, it was found that sand and dust were generated between the two sites. As a result, the mobile observation was successful and the effectiveness of this method was shown. Since this is the first year of research, preparations for the next fiscal year observation and more detailed data analysis should be advanced. However, due to the spread of COVID-19, it is undecided whether observation could be conducted in May 2020.	

一般研究 34 General Research 34	対応教員 Corresponding Staff	石井　孝佳 Ishii, Takayoshi
研究代表者 Principal Researcher	内藤　健（農研機構遺伝資源センター） Naito, Ken (Genetic Resources Center, NARO)	
研究課題 Research Subject	*Vigna* 属野生種の耐塩性に関するスクリーニングと形質評価 Screening and physiological analysis on salt tolerance in wild *Vigna*	
共同研究要旨 Summary of Joint Research	Genus *Vigna*, close relatives of cowpea and azuki bean, consists of more than 100 species that are highly adapted to harsh environments, including marine beach. Thus, the wild species of this genus is a great resource of tolerance and resistance to abiotic and biotic stresses. Currently we have been focusing salt tolerance but accessions of Vigna vexillata remain unsurveyed to date. As such, in this project, we screened 104 accessions of Vigna vexillata, that are available through NARO genebank. Of them, our primary screening identified 8 accessions that survived more than 2 months under a condition of 200 mM NaCl.	

一般研究 35 General Research 35		対応教員 Corresponding Staff	辻本　壽 Tsujimoto, Hisashi
研究代表者 Principal Researcher	児玉　基一朗（鳥取大学大学院連合農学研究科） Kodama, Motoichiro (The United Graduate School of Agricultural Sciences, 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	*Elymus tsukushiensis* and *El. racemifer* plants were collected in various parts of Japan. After hard surface sterilization, the plant tissues were placed on a PDA medium and the growing mycelia were subcultured to isolate *Epichloë* endophytes. Colony and spore morphology of the isolated strains were observed. After decolorizing and aniline blue staining of the leaf sheath or seeds of the collected plants, mycelial growth of the endophytes in the plant tissues was observed under microscope. Endophyte DNAs were extracted from each colony on the plates and rDNA ITS region, β-tubulin gene and TEF 1-α gene were sequenced for phylogenetic analysis. Furthermore, secondary metabolite biosynthesis abilities of the *Epichloë* spp. were examined by PCR analysis for toxin gene clusters. The *dmaW*/*lpsB*, *idtG*/*idtQ*, *lolC*/*lolA* and *perA* genes, which are involved in ergot alkaloids (E) (vertebrate toxin), indole-diterpenes (vertebrate toxin), lolines (L) (insect toxin) and peramine (P) (insect toxin) biosynthesis respectively, were examined by multiplex PCR methods. As results, endophyte candidate strains were isolated from over 130 *El. tsukushiensis* and *El. racemifer* plants. Molecular phylogenetic analysis revealed that all *Epichloë* spp. isolated from those *Elymus* plants are *E. bromicola*. The multiplex PCR analysis also revealed that those strains include E/P, L/P and P type strains. Production and accumulation of P by P-type strain in infected plants were observed by HPLC analysis, indicating that the strain should be good candidate strain for introduction to wheat plants.		

一般研究 36 General Research 36		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	大規模太陽光発電パネル群周りの風環境に関する風洞実験 Wind tunnel experiment on flow field around large-scale photovoltaic panel arrays		
共同研究要旨 Summary of Joint Research	To analyze an effect of solar panels configuration on wind profile around the panels, wind tunnel experiments were carried out in case that wind with a constant speed flow in the tilted solar panels set in a single file. The model size and arrangement condition of tilted solar panels were surveyed. The model size of tilted solar panels was selected in the range of 1/15 to 1/20 scale with reference to the practical tilted solar panels constructed on the ground. The size of model plate in wind tunnel test was decided 60mm length x 320mm wide x 2mm thick. The model plate was arranged with tilt angle of 30° and a single file with the interval of 120mm. The wind speed on the wind tunnel experiment were set in the range of 2m/s to 10m/s. The wind speed was measured by a hot wire anemometer at 99 points set at around the tilted plates and downstream of the plates. As the presentative experimental results, it was confirmed that wind speeds around upper and lower edge were increased in the range of 5% to 10% compared with the inlet speed (10m/s) of upstream side from the plate in the case of a tilted plate. It was also found the wind speed backside of the panel was decreased in the range of 70% to 80 % at the same wind condition. In the case of four tilted plate in a single plane, it was shown that separated flow generated at the first panels retouched at the third and fourth panels.		

一般研究 37 General Research 37		対応教員 Corresponding Staff	木村　玲二 Kimura, Reiji
研究代表者 Principal Researcher	松岡　延浩（千葉大学大学院園芸学研究科） Matsuoka, Nobuhiro (Graduate School of Horticulture, Chiba University)		
研究課題 Research Subject	フェノタイピングを用いた農作物の水分ストレス検出システムの開発 Development of detection system for water stress of crops by phenotyping		
共同研究要旨 Summary of Joint Research	In arid regions, the proper timing of irrigation is important from the point of view of water conservation. A number of moisture stress detection systems using stomatal resistance, leaf temperature, and near-infrared reflectance have been proposed and put to practical use in the field in developed countries. However, due to the difficulty of maintaining the sensor and the price, it is rarely used for plots in developing countries, such as those found in Dkhla Oasis, Egypt. In recent years, advances in visualization and AI technologies have been brought about by the low cost of imaging sensors and the high speed of computers, and phenotyping is becoming possible. Initially, Egyptian clover was planned 1/2000a wagnel pots in the glass room of the Dryland Research Center of Tottori University and the Department of Horticulture of Chiba University, but due to the difficulty in regulating moisture stress, experiments were carried out with sweet potatoes at Chiba University. Six multispectral cameras (visible and near-infrared camera modules (Raspberry Pi Camera V2, Raspberry Pi NoIR Camera V2) and thermal infrared camera modules (Lepton 2.0) controlled by a microcomputer (Raspberry Pi 3B) created by Matsuoka et al. (2018, Tottori University Arid Land Research Center Collaborative Publication 29C2015) (parts purchased at this expense) were used to photograph the specimen plants using multispectral images (R, G, B, IR, thermal infrared) of the specimen in (1). The images obtained here were used with Metashape (Agisoft, existing) to determine a reasonable camera system position and proper exposure to 3Dize the plant body for each of the R, G, B, IR, and thermal infrared images.		

一般研究 38 General Research 38		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	モンゴル森林ステップの植生劣化過程における土壌養分動態変化メカニズムの解明 Clarification of soil nutrient dynamics in vegetation degradation process of Mongolian forest step		
共同研究要旨 Summary of Joint Research	In Mongolia, vegetation degradation and desertification have progressed because of climate change and human activities, and vegetation has not recovered in many areas. Nutrients cycle in the underground also changed with degradation of aboveground vegetation. However, the mechanisms and linkage of above- and belowground activities were still not clear. In this research project, a total of six transects were set up in the Udleg experimental forest station managed by the National University of Mongolia. We selected different vegetation types from forest to grassland and set up for 30 plots in total. A soil (5 and 15 cm depth from the ground surface) and plant leaves were collected from each site. The nitrogen concentration and the isotope ratio in the soil and in each of the plant leaves were measured. As a result, the nitrogen concentration in soil decreased continuously from the forest to the grassland, and at the same time the chemical form of nitrogen changed. Ammonia nitrogen was high in forest soil and nitrate nitrogen was high in grassland soil. Nitrogen concentrations and isotope ratios in leaves of plant species appearing in the grassland differed greatly depending on the location, and it was considered that they may have changed reflecting the state of nitrogen in the soil. Next year, we plan to further increase the number of survey sites and samples and verify that other regions will achieve the same results as this year.		

（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	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	小型 PM2.5 センサーを用いたゴビ砂漠におけるダスト観測ネットワークの構築 Development of dust observation network in the Gobi Desert using compact PM2.5 sensors
共同研究要旨 Summary of Joint Research	We have developed a compact dust sensor using a PM sensor developed for air cleaners by SHARP and started test observation at the ALRC Tsogt-Ovoo observation site in the Gobi Desert since the last academic year. In this academic year, we collected the test observation data and replaced the inside battery. In addition, we analyzed and compared the data with a sophisticated dust sensor (TSI DustTrak) installed at the same site to evaluate the performance of the compact dust sensor. 1) In May 2019, we collected the test observation data at the ALRC Tsogt-Ovoo observation site and replaced the inside battery so that the test observation restarted. In May 2020, we planned to collect the test observation data from May 2019 and discuss building dust observation network in the Gobi Desert, but these plans were cancelled due to the new coronavirus. 2) We analyzed and compared the test observation data in March 2019 with the observation data of a DustTrak on the same pole to evaluate the performance of the compact dust sensor. This dust sensor was able to work for 12 days with the fully charged mobile battery (20,000 mAh). On 18 March, the dust sensor could capture a dust event with high PM10 concentration measured by the DustTrak, which shows that it has the capability to detect dust events. As the next step, we can start to build a dust observation network in the Gobi Desert using the compact dust sensors which we developed.

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（国立研究開発法人国立環境研究所生物・生態系環境研究センター） Akaji, Yasuaki (Center for Environmental Biology and Ecosystem Studies, National Institute for Environmental Studies)	
研究課題 Research Subject	マングローブ稚樹の根に共生する内生菌および菌根菌の空間分布と機能の解明 Spatial distributions and roles of root endophyte and mycorrhiza fungi associated with mangrove saplings	
共同研究要旨 Summary of Joint Research	We conducted the direct observation of arbuscular mycorrhizal fungi (hereafter, AM fungi) using a microscope and genetic analysis (metagenomics) to elucidate the relationships between two Rhizophoraceae mangrove plants (*Rhizophora stylosa* and *Bruguiera gymnorhiza*) and AM fungi. The genetic analysis was conducted using the next-generation sequencing (Ion PGM) in Arid Land Research Center, under the guidance of Dr. Takeshi Taniguchi. As a result of observations using a microscope, we found no infection of AM fungi in the roots of nine *R. stylosa*, whereas we found arbuscules in the roots of three *B. gymnorhiza* out of 23 individuals observed. On the other hand, as a result of genetic analysis, DNA sequences from genus Glomus were mainly detected in the roots of both plants compared to the other genera such as Acaulospora. In addition, Glomus and Acaulospora had positive and negative associations with soil EC, respectively ($P < 0.05$). By combining these analyses, we also found that the group of AM fungi infecting *B. gymnorhiza* roots was not Glomus but Acaulospora. Consequently, our results suggest that *R. stylosa* is not likely to form symbiotic relationships with AM fungi despite the presence of DNA sequence from Glomus whereas *B. gymnorhiza* is likely to form a conditional symbiotic relationship with Acaulospora in sites with relatively low salt concentration.	

若手奨励研究 3 Incentive Research by Young Scientists 3	対応教員 Corresponding Staff	黒崎　泰典 Kurosaki, Yasunori
研究代表者 Principal Researcher	大西　一成（聖路加国際大学公衆衛生大学院環境保健学分野） Onishi, Kazunari (Graduate School of Public Health, Environmental Health, St.Luke's International University)	
研究課題 Research Subject	モンゴルにおける黄砂・大気汚染物質濃度上昇イベントにおける健康影響評価 Adverse health effect of Asian dust and air pollution in Mongolia	
共同研究要旨 Summary of Joint Research	There are concerns about the health effects of Asian dust (mineral dust) originating in arid areas such as the Gobi Desert and the Taklimakan Desert. In this study, we will evaluate the health effects of Asian dust and local air pollution. Especially, we conducted a survey of subjective symptoms in Mongolia population supposed to have high exposure concentration, evaluate the daily environmental status and clarify that cause health effects. Furthermore, the preventive behavior (wear mask, air purifier, go outside) is considered as possible	

	confounders. The survey was conducted in 3 seasons: October 2018 (normal contamination date), January to February 2019 (day of serious contamination), and May 2019 (DSS season). The total number of participants recruited was 90 (Ulaanbaatar) and 80 (Zamyn Uud). Because few participants were taking preventive action, these data were not included in the analysis. An analysis using a CART (regression tree) model showed that ocular, nasal, and throat symptoms appeared in Ulaanbaatar when the air temperature was high and the oxidant concentration was high, and skin symptoms appeared when the dust concentration was high. In Zamyn Uud, it was shown that symptoms of ocular, nasal, throat and skin symptoms appeared when dust concentration was high. In Ulaanbaatar, health effects were caused mainly by high concentrations of airborne contaminants, and skin symptoms developed when dust was frequent. In Zamyn Uud, dust was responsible for most of the symptoms, as there were more days of dust exposure and higher concentrations than in Ulaanbaatar. In other words, it was confirmed that subjective symptoms were caused by high concentrations of the main pollutant species in the area. We will continue to collect and analyze the questionnaire surveys conducted in autumn, winter and spring 2019 and 2020.

若手奨励研究 4 Incentive Research by Young Scientists 4	対応教員 Corresponding Staff	恒川　篤史 Tsunekawa, Atsushi
研究代表者 Principal Researcher	石本　雄大（青森公立大学地域連携センター） Ishimoto, Yudai (Regional Collaboration Center, Aomori Public University)	
研究課題 Research Subject	アフリカ砂漠化前線地域における共有地利用と土地制度 Communal Land Use and Land System in Semi-Arid Africa Affected by Desertification	
共同研究要旨 Summary of Joint Research	Literature review for Zambian land policy and its interview survey were conducted. Their results were mainly three points based on the study in last physical year: 1) Changes in Land Policy: There were three regime of land administration in Zambia (Oyama 2016); In the colonial administration, rural people lived on communal land by customary law, whereas European settlers owned private property by modern law (Mamdani 1996). In the regime on economic socialism after independence, the 1975 Land Act declared that all land in Zambia shall be vested in the President. The act abolished all freehold estates to statutory leases during 100 years. The 1995 Land Act provides for the statutory recognition and continuation of customary tenure, provides for the conversion of customary tenure into leasehold tenure (NAZ 1995). 2) Problems after the 1995 Land Act: Fencing and Land Grabbing 2-1. Fencing: Fencing in most customary areas, was traditionally prohibited for the reason for the exclusion of people with secondary rights to land, such as the grazing rights, but now is a growing practice which is meant to fix the boundaries of land (Chitonge et al. 2017). The negative impact is concerned such as land degradation and social conflict. 2-2. Land Grabbing: Zambia Development Agency was established in 1996 to facilitate the transfer of customary lands to foreign investors through ‘farm block concept’ (Castel and Kamara, 2009). For example, the chief permitted to convert 26,000 ha from customary to state owned lands for a British/Zimbabwean joint venture, which resulted in 2,000 families in five villages becoming displaced people. Thus, life of residents may be threatened by the chiefs and the government agency (Mousseau and Mittal 2011). 3) Discussion of Countermeasures for the problems 3-1. Supporting the smallholders by nongovernmental organization: Zambia Land Alliance (ZLA) is a network of NGOs, which helps family reclaim the land grabbed. Moreover, it proposes a revision of land law (3-2). 3-2. Revision of Land Law: Formalization of group rights over rural lands may be a faster way of securing rights, where there is pressure from 'land grabbing' or 'resource degradation' (Hilhorst 2010). However, in Zambia, there are no clear rules for regulating group rights over common land in land law. Therefore, Zambian Government has started to prepare new National Land Policy, stakeholders have participated to consult areas for improvement and proposed a revision of land law (MOLA 2018, ZLA2016): It emphasizes the necessity for registration in land either as group land rights or as individ-	

	ual private land, and for protection of customary interest in communal land. However, the draft land policy has not been submitted to cabinet for approval because of rejection by the house of chiefs. Traditional leaders rejected the draft on the grounds that it was trying to temper with the Chieftaincy (Lusaka Times 2018, ZLA 2016). Minister of Lands and Natural Resources told her ministry anticipated to finalize the National Land Policy in the third quarter of 2019 (News Diggers 2019). However, situation is fluid whether the draft is approved or not hereafter. 3-3. Future work: If the Draft National Land Policy will be approved, it should be important to grasp the process for registration of group land tenure.

若手奨励研究 5 Incentive Research by Young Scientists 5	対応教員 Corresponding Staff	辻本　壽 Tsujimoto, Hisashi
研究代表者 Principal Researcher	佐久間　俊（鳥取大学農学部） Sakuma, Shun (Faculty of Agriculture, Tottori University)	
研究課題 Research Subject	環境変化に適応する穂形質可塑性の分子機構の解明 Elucidation of molecular mechanism of inflorescence plasticity adapting to environmental change	
共同研究要旨 Summary of Joint Research	Inflorescence shapes are a key determinant of the final grain number and size in cereal crops. Barley inflorescences are mainly classified into two-types; two-rowed and six-rowed. Among six-rowed barley cultivars, Ethiopian landraces called "*labile*" represent irregular floret abortion during spike development. However, little is known about the genetic basis of the *labile*. In this study, detail phenotypic analysis has been performed to understand the *labile*. The floret abortion was observed during early spike growing stage; stamen primordium stage. The phenotype was only found in the lateral spikelets although there are no trends of the positions of spikes or tillers. The number of floret abortion in the lateral spikelets increased when the plants were grown in sand-field of ALRC compared to normal soil-field of Faculty of Agriculture, Tottori University. This result suggest that sand-field lack the element (s) to suppress the *labile* phenotype.	

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	徳本　家康（佐賀大学農学部） Tokumoto, Ieyasu (Faculty of Agriculture, Saga University)	
研究課題 Research Subject	乾燥地農業における局所耕うん法の適用性の評価と改良 Improvement and evaluation of the applicability of shaft tillage method for arid land agriculture	
共同研究要旨 Summary of Joint Research	Objectives: For improvement and evaluation of the applicability of the shaft tillage method to arid land agriculture, ①we evaluated root water uptake and downward flow of water through the artificial macro-pore. and ②root distribution and effect of the shaft tillage method on hydraulic properties of root system were investigated. Additionally, field experiments of shaft tillage method were carried out. Results: a. Root distribution in-and-out of an artificial macro-pore: Column experiments showed high density roots in the artificial macro-pore. The dry matter content of roots and leaves were found to be higher after use of the shaft tillage method as compared to the method without an artificial macro-pore. b. Root water uptake and downward water flow As determined in the water balance analysis of water flow experiments, most of the water uptake came from roots in the lower depth of the soil profile, suggesting important contributions of the high density roots to transpiration. Additionally, in the macro-pore experimental condition, we observed preferential water flow through the high density roots, indicating a shift to deeper sources of water for plant growth. c. Field experiments We worked on field experiments to compare plant growth between control and the tillage-method-plots. As a result, pest damage of the control plot was found. At the tillage-method-plot, however, there was no pest damage. To evaluate effects of the different root system on plant productiv-	

	ity, we would need nutrient analysis in the aspect of plant physiology.

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	金　俊植（理化学研究所環境資源科学研究センター） Kim, June-Sik (Center for Sustainable Resource Science, RIKEN)		
研究課題 Research Subject	環境耐性型コムギの網羅的代謝産物および遺伝子発現のダイナミックス解析 Analysis of metabolome and transcriptome dynamics on environmental resilient wheat cultivars		
共同研究要旨 Summary of Joint Research	This project aims to elucidate the temporal dynamics of wheat metabolome and transcriptome against abiotic stresses, heat and drought. In this year, as a pilot experiment, we treated abscisic acid (ABA), a kind of plant hormones mediating the inter/intracellular drought stress signal, to 4-week-old Norin 61 wheat plants by spraying, then the mature leaves were sampled by a time schedule (2, 6, 12-hour) and subjected to mass spectrometry (MS) quantifying >100 secondary metabolites. We found the result of biological replicates in each experiment varied seriously, the difference among replicates were bigger than that by the ABA treatment. Following mRNA-seq analysis outputted the similar results. The inter-replicate variance disturbed to extract the differentially expressed genes (DEGs), only few DEGs were retrieved and the number was not sufficient to analyze the global dynamics. On the other hand, the similar approach was achieved with the selected synthetic wheat lines known to being heat resilient. The MS analysis with the mature leaf samples after 3-hour heat treatment resulted the acceptable variance among biological replicates, significant accumulation of metabolites sharing the same biosynthesis pathway (e.g. pyruvic acid and ascorbic acid). Encouraged by this result, we are now working on the mRNA-seq analysis with a time-line (3, 12, 24-hour) heat treatment. We successfully prepared the mRNA-seq libraries of 51 samples with a proper quality, and now the sequencing is on progress.		

若手奨励研究 8 Incentive Research by Young Scientists 8		対応教員 Corresponding Staff	山中　典和 Yamanaka, Norikazu
研究代表者 Principal Researcher	吉原　佑（三重大学生物資源学研究科） Yoshihara, Yu (Graduate School of Bioresources, Mie University)		
研究課題 Research Subject	モンゴルの降水パターンが牧草の栄養価を介して家畜のエネルギー収支に及ぼす影響 The effect of Mongolian rainfall pattern on energy balance of livestock through grass nutritive values		
共同研究要旨 Summary of Joint Research	The aim of this study is examining the effect of Mongolian rainfall pattern on energy balance of livestock through grass nutritive values. We estimated the energy intake and energy loss of Mongolian grazing sheep during summer and explored the actual nutrition conditions. Energy intake was calculated as the bite mass × number of bites × forage metabolic energy. Actual sheep nutrition indicators such as chest width, body weight, and albumin, total protein in blood were investigated. Bite time, bite size, and feed metabolic energy were 12094, 61 mg, and 1.16 Mcal/kg, respectively, and thus total energy intake was 0.84 Mcal. The daily energy loss from maintenance, grazing, coldness, and pregnancy were 1.58, 1.56, 2.68, and 0.41, respectively, and thus the total energy loss was 6.23 Mcal. The total protein and albumin content in the blood decreased by 30 % and 54.7 %, respectively, and the sheep lost 70.7 % in the total body fats during winter.		

(5) 研究集会／ Research Meeting

研究集会 1 Research Meeting 1		対応教員 Corresponding Staff	辻本　壽 Tsujimoto, Hisashi
研究代表者 Principal Researcher	宅見　薫雄（神戸大学農学研究科） Takumi, Shigeo (Graduate School of Agricultural Science, Kobe University)		
研究課題 Research Subject	タルホコムギの乾燥地農業適性のパンコムギへの効率的導入に関する研究打ち合わせ Efficient introduction of dryland farming-related traits from wild diploid progenitor to bread wheat		

共同研究要旨 Summary of Joint Research	This meeting was held at Arid Land Research Center, Totori University, on June 12 and 13, 2019. Seven researchers from four universities and one international agriculture research institute (CIMMYT, Mexico) participated in the meeting. The goal of the meeting was to discuss how we could better use wild wheat genetic resource (especially, the *Aegilops tauschii* resource) to broaden the genetic diversity of modern cultivars in order to accelerate wheat breeding programs and to counter global climate change and extreme environmental conditions including severe aridity. For this goal, seven talks were provided to review the latest related topics. In the Day1 session, five speakers talked on the importance of *Ae. tauschii* genetic resource in wheat breeding, recent advance in genetic studies on *Ae. tauschii*, and new findings on the physiology of drought tolerance in wheat. In the Day2 session two speakers talked on new methods for haploid wheat production and its application current status of the studies on homoeological pairing and genetic re-combination in wheat. To conclude, the participants discussed what they could do to widen the genetic diversity of modern cultivars based on the latest technologies and resources. Furthermore, they recognized the need for improved statistical approaches that enable association of phenotypic variation with genetic variation. In addition, they agreed that they would seek to obtain funding for the studies to promote the use of *Ae. tauschii* genetic resource in wheat breeding programs for dryland agriculture.

研究集会 2 Research Meeting 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	古写真から読み解く環境問題 Environment Issues and Old Photographs	
共同研究要旨 Summary of Joint Research	We held the meeting on the old photographs of Mongolian plateau and discussed deeply from various angles how to use these old photographs in order to analyze the environment issue. We finally settled the research process that for the first step we will focus on construction of the capital city and destruction of around forests. 1) We can collect the old photos from various explores' travel books to show huge amount of woods have been cut off for the construction and firewood. These materials may be the eloquent evidence of images that show deforestation; one of the environment issues. 2) We can also use the satellite images for grasp the areal development of city and also areal destruction of forests nearby the city. 3) We can combine the two kinds of images; old photographs and satellite to integrate areal data of towns and woods for farther analysis. 4) We have arranged the corpus of old photos for environment issue. We can use them next step to understand the change of vegetation in Mongolia. Furthermore, we will be able to make the appropriate cooperative research project both for natural sciences and humanities through integrating the data of weather for forty years and narrative of nomads on the crisis of weather.	

（6）海外研究者招聘型共同研究／ Guest Research Associate for Joint Research Program

海外研究者招聘型共同研究 1 Guest Research Associate for Joint Research Program 1	対応教員 Corresponding Staff	谷口　武士 Taniguchi, Takeshi
研究代表者 Principal Researcher	マルワ　ハーテム　エルタヒル　エルナエム（ハルツーム大学・農学部・植物学および農業バイオテクノロジー学科） Marwa Hatim Eltahir Elnaiem (Department of Botany and Agricultural Biotechnology, Faculty of Agriculture, University of Khartoum)	
研究課題 Research Subject	スーダン、ハルツーム州の異なる土壌および土地利用タイプにおける菌類群集のメタバーコーディングに関する研究 Metabarcoding of Fungal Communities in Different Soil and Land-use Types in Khartoum State, Sudan	

共同研究要旨 Summary of Joint Research	The research was conducted to study the effect of different soil and land-use types on the fungal community in Khartoum State, Sudan using metabarcoding approach. 90 samples were collected in both summer and winter from four different sites in Khartoum State and from different land-use types in each site in triplicates. Each site was chosen to represent different soil type. The DNA was extracted from soil samples using Qiagen Dneasy PowerSoil DNA extraction Kit. And the DNA extraction was used to amplify the internal transcribed spacer 1 (ITS1) region of the rRNA gene of fungi. The purified ITS1 amplicons were subjected to sequencing using Ion Torrent platform (Ion OneTouch 2 system). The sequencing raw data was analyzed using the DADA2 package in R software. The total number of Amplicon Sequence Variants (ASVs) after filtering was 8413 (merged in distinct 993 taxa). The exploratory analysis showed different distribution and abundance of taxa among communities. 16 fungal phylum were recorded in the data, with the Ascomycota representing the most abundant phylum (59.72%). The data analysis indicated that the different land-use types were highly significantly different (*P* value 0.00279) in their taxonomic diversities. While, the soil types did not show significant difference (*P* value 0.256). Then, TukeyHSD was used to examine the statistical difference between group levels. The land-use types grouped in three groups regarding their taxonomic diversity. Bray-Curtis dissimilarity measure was used to compare the composition of different communities, which were visualized using NMDS ordination. The multivariate analysis result indicated significant distance differences between both Land-use types (*P* value 0.001) and soil types (*P* value 0.001). However, no significant differences were obtained between seasons (*P* value 0.13). All of the ALRC facilities that I used helped me to complete my research within few days and generate data that could be published in good journal.

海外研究者招聘型共同研究 2 Guest Research Associate for Joint Research Program 2	対応教員 Corresponding Staff	安　萍 An, Ping
研究代表者 Principal Researcher	ビクトリア　オコ　オテエ（ナイジェリア国カラバ大学農林野生資源管理学院土壌科学学部） Victoria Oko, Otie (Department of Soil Science, Faculty of Agriculture, Forestry & Wildlife Resources Management, University of Calabar, Nigeria)	
研究課題 Research Subject	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 Ameliorative effects of brassinolide on growth, nutrition, antioxidase activity and yield of Soybean under salinity stress	
共同研究要旨 Summary of Joint Research	Brassinolide (BR) is a kind of plant hormone. It has been reported to promote plant growth and induce stress tolerance in plants. However, its effects on plants under salinity stress has not been reported. This study investigated the promoting effect of BR on germination and growth of soybean under salinity. Experiment 1: Germination experiment: The BR was applied to the soybean seeds and germination rate was determined. Experiment 2: The optimal stage for BR application: This experiment was conducted in the greenhouse. Soybeans were grown in pots and saline water were irrigated into the pots. Four (4) levels of salinity [tap water (control), 30, 60 and 90 mM] were used in combination with 6 application frequencies of BR [control (no application), application at seedling, flowering, podding, seedling + flowering and seedling + flowering + podding stages]. The plants were grown to full maturity. The electrical conductivity of the soil extract (ECe) was determined at 2-week interval till the end of the experiment. Data were collected periodically on the following growth and yield variables: a). Plant height, number of leaves, leaf area, leaf area index (LAI), specific leaf area (SLA), number of tillers, number of days to booting and flowering, plant biomass (leaves, stem and grains), number of branches, pods and seeds per plant, yield components, grain yield. b). Plant physiological data include: relative water content in leaves (RWCL), protein and N contents in seeds, chlorophyll contents, photosynthetically active radiation (PAR), stomatal conductance, anti-oxidative enzyme activity [Superoxide dismutase (SOD), Peroxidase (POD), Ascorbate peroxidase (APX)], shoot and root contents of : Na, K, Ca and Mg, K+/Na+ (root and shoot ratios) were also determined using appropriate procedures and equipment. Laboratory analysis of plant samples were carried out at the ALRC Eco-physiology Lab, using standard laboratory procedures, while the total N uptake in soybean seeds were conducted at the Department of Soil Science Research Laboratory, University of Calabar, Nigeria.	

(7) 海外拠点連携型国際共同研究／ International Joint Research with Overseas Institutions

海外拠点連携型国際共同研究 1 International Joint Research with Overseas Institutions 1	対応教員 Corresponding Staff	恒川　篤史 Tsunekawa, Atsushi
研究代表者 Principal Researcher	薛　娴（中国科学院西北生態環境資源研究院） Xue, Xian (Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences)	
研究課題 Research Subject	青海チベット高原における高山草甸劣化の要因とメカニズム Cause and mechanism of alpine meadow degradation in the Qinghai-Tibet Plateau	
共同研究要旨 Summary of Joint Research	In 2019, we clarified the three typical processes of desertification in alpine grassland and their dynamic mechanisms by the field observation and indoor experiment. 1) Grassland desertification along the rivers and lakes is a dominated process of fixed dunes activation. Under the dual effects of climate warming and overgrazing, vegetation on the dunes has rapidly degraded, fixed dunes have been activated, and some lakes have dried up, forming large swaths of mobile dunes. 2) The alpine grassland degenerated into sand/gravel surface on the top and sun slope of mountains is mainly controlled by the freeze-thaw-water-wind combine erosion process. The freezing and thawing process is more intense and frequent in the sunny slope than the shady slope and piedmont zone. Climate warming has exacerbated the freezing and thawing process and has caused gaps in the surface. Along the gap, the erosion began to take effect and strengthen, forming the sandy/gravel surface. 3) Alpine grassland degradation in the foothills mainly began with vegetation degradation caused by the combined effects of climate warming and overgrazing. Vegetation degradation first manifested as the succession of community structure. Poisonous weeds gradually replaced the sedges and grasses. Because the weeds have not the turf layer, thus cannot resist the erosion, which makes the surface rough. The roughened surface makes the heat and water migration process intensified. Therefore, the shallow surface is further dry, and the ecosystem degraded. We revealed the hydrothermal dynamics mechanism of desertification and recognized its critical ecological processes. The study shows that desertification changes soil properties, strengthens the transport of water and heat, and further intensifies the desertification process of grassland.	

(8) 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	辻本　壽 Tsujimoto, Hisashi
研究代表者 Principal Researcher	飯泉　仁之直　（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） Iizumi, Toshichika (Institute for Agro-Environmental Sciences, National Agriculture and Food Research Organization (NARO))	
研究課題 Research Subject	気候変動下の高温ストレスに対するスーダンのコムギ生産の適応:広域作物モデリングによる評価 Adaptation of wheat production in Sudan to heat stress under climate change: an assessment based on large-area crop modeling	
共同研究要旨 Summary of Joint Research	We submitted the following manuscript generated from this joint research to an international journal, and it is in review at the timing of writing this report. The title, authors and abstract of the manuscript are as below: Title: Challenges in the world's hottest wheat-producing environments of Sudan related to rising temperatures and increasing demand Authors: Toshichika Iizumi, Imad-Eldin A. Ali-Babiker, Mitsuru Tsubo, Izzat S. A. Tahir, Yasunori Kurosaki, Wonsik Kim, Yasir S. A. Mohammed, Amani A. M. Idris, and Hisashi Tsujimoto. Abstract: Recent and projected warming poses challenges for food production at low latitudes, particularly in arid regions. Wheat demand in Sudan could triple by 2050. In the country, the world's hottest wheat-growing environments occur, and observed yield declines in hot seasons are encouraging the national government to prepare for a warming of 1.5–4.2 °C. Here, we show that despite the use of adjusted sowing dates and existing heat-tolerant varieties, in 2050, the domestic production share will decrease from 16.0% to 4.5%–12.2%. In the relatively cool northern region, yields will need to in-	

	crease by 3.1%–4.7% per year, at noncompounding rates, to meet demand. In the hot central and eastern regions, improvements in heat tolerance are essential. Yields under high-temperature conditions need to increase at a 0.2%–2.7% rate per year to keep pace with warming. These targets are provided for stakeholders to address the wheat supply challenge.

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	長期データから読み解くモンゴル草原植生の気候変動に対する応答 Long-term data analysis on the vegetation responses to climate changes in Mongolian grasslands	
共同研究要旨 Summary of Joint Research	Understanding ecosystem responses to climate change and predicting future ecosystem changes necessitate a time-series analysis of long-term data because climate change is an on-going phenomenon. Given the deficiency of such a time-series analysis, we know little about how ecosystems respond to future climate change and how we can manage ecosystems under climate change. Mongolian grasslands cover the central part of eastern Eurasian steppe, and forage resources there support livestock production in Mongolia. Mongolian grasslands would also play an important role as a sink for atmospheric carbon in terrestrial ecosystems due to high productivity and slow decomposition processes in these grasslands. Currently, however, we know little about how forage resources have changed under climate change and what factors drive their changes. The answer to these two questions is practically important for the future use of Mongolian grasslands and will therefore have profound societal impacts particularly for the communities of local herders. In this study, by using the long-term time series data collected across Mongolia since 1960s, we applied a dynamic empirical modelling approach by which we can examine causal relationships among focal variables in the time series data. Although many previous studies on the consequences of climate change on ecosystems focused mainly on increasing temperature, this study explores the ecological consequences of multiple facets of climate change, including temperature changes, precipitation changes, and variabilities of temperature and precipitation for more than five decades. Our results clearly demonstrated that annual precipitation and SPEI drive vegetation productivity. Moreover, the inter-annual variabilities of precipitation and SPEI drive 5-yr mean of vegetation productivity. These results suggest that increasing aridity and its variability in future will have direct influences on vegetation productivity across Mongolia.	

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（国立研究開発法人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	全球気候モデルの実験データを用いたアジア・アフリカ乾燥地の将来気候解析 Analysis of future climate in drylands in Asia and Africa using outputs of global climate model experiments	
共同研究要旨 Summary of int Research	Future climate change in the Asia-Africa dryland was investigated for RCPs 4.5 and 6.0, and the results showed that (1) outputs of temperature, precipitation, NPP and LAI were between RCPs 2.6 and 8.5, (2) NPP and LAI tended to increase, (3) in many cases, the difference between RCP4.5 and 6.0 was small, and (4) dry and wet areas were consistent across scenarios in many models. We also assessed terrestrial carbon cycle by using the multiple terrestrial ecosystem models (TRENDY dataset) and multiple observational data sets (MODIS sensor data and machine-learning based estimation) and revealed recent significant reductions in photosynthesis and land carbon uptake. Satellite data show different results in different versions, and in the latest version larger photosynthesis is observed. In addition, we carried out experiments with regional climate models (RCMs) forced by ECMWF reanalysis (ERA15) in 1986-2005, and by RCP4.5 experiments by ECHAM5 and HadGEM2 in CMIP5 for dynamical downscaling into 30km resolution over Mongolia for 1986-2005, 2016-2035, 2046-2065 and 2081-2100 periods, and compared the results with observation (in air temperature, precipitation,	

	wind speed etc.) at 59 meteorological stations after bias correction based on delta quantile methods. Future changes of extreme climate indices were also estimated at Tsogt-ovoo and Ulaanbaatar (UB). Further, we performed pseudo global warming experiments for heavy rain events in Julys in 2015 and 2016 around UB using an RCM forced with CMIP5's MPI-ESM-MR data (RCPs 2.6 and 8.5) with anomalies for the two periods in the future. For RCP 8.5, rainfall in the whole study domain reduced in around 20% for 2046-2065, and a part of the mountainous region tended to have rainy areas with heavy rainfall. We have submitted a paper on regional precipitation comparison between RCM and multiple precipitation products.

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, 2020

国名等 Country/Region	機関名	Names of Institutions
中国 China	北京林業大学	Beijing Forestry University
	北京師範大学	Beijing Normal 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一般及び実験生物学研究所	Institute of General and Experimental Biology, Mongolian Academy of Sciences
	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	The 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

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－2020 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、シグダフ・メクリアウ）・アムハラ州農業研究所アンダサ畜産試験場（アデババイ・ケベデ）・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（侯扶江）・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。同検知器による計測は、呼吸試験装置を用いて中国で検証した。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が提示された。

ササゲの半数体作成法の確立

期間：2019 年 4 月－2020 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）
研究費：ライプニッツ植物遺伝学研究所、クイーンズランド大学（ビル＆メリンダ・ゲイツ財団助成金）
課題：ササゲ（*Vigna unguiculata*、2n＝2x＝22）は、アフリカで重要なマメ科作物であり、干ばつや熱ストレスに対して強い耐性を持っている。 半数体（倍加半数体）は、植物育種を促進するのに非常に強力な手法である。 本共同研究では、セントロメア特異的ヒストン H3（CENH3）の操作によるササゲの半数体生産法を確立する事を目標にした。ササゲは、二倍体ゲノム中に 2 種類の CENH 3 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。

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（山中典和、黒崎泰典、衣笠利彦、辻本壽、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。

(2) International Joint Research

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

Period: Jun. 2019 - May. 2020
Leader: A. Tsunekawa (ALRC, Tottori University)
Organization: Tottori University (A. Tsunekawa, N. Kobayashi, S. Mekuriaw), Andasa Livestock Research Center, Amhara Regional Agricultural Research Institute (A. Kebede), Bahir Dar University (F. Tegegne, Y. Mekuriaw), Lanzhou Univeristy (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 JST and 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. Determination of the CH_4 emissions by LMD was validated in China by measuring the CH_4 production in respiration chambers using the cattle. Increases in the milk yield without increases in CH_4 emissions suggested confined feeding as an alternative to conventional grazing in drylands.

Establishment of haploid inducer in cowpea

Period: Apr. 2019 - Mar. 2020
Leader: T. Ishii (ALRC, Tottori University)
Organization: Tottori University (T. Ishii), Leibniz Institute of Plant Genetics and Crop Plant Research, Germany (A. Houben), The University of Queensland (A. Koltunow)
Funding: Plant Genetics and Crop Plant Research and sub-award from the University of Queensland for the grant ‘Hy-Gain‘ from the Bill & Melinda Gates Foundation (USA).
Subject: Cowpea (*Vigna unguiculata*, 2n=2x=22) is an important legume crop in Africa, and has a pronounced tolerance to drought and heat stress. Haploids (doubled haploids) are very instrumental to accelerate the plant breeding process. We intend to establish a haploid production method for cowpea via manipulation of the centromere-specific histone H3 (CENH3) variant. Cowpea encodes two types of CENH3s in the diploid genome. Manipulation of cowpea CENH3s is in progress.

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, H. Tsujimoto, 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

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 7 月－2019 年 12 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、中原浩貴、邵揚）
研究費：鳥取大学
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検討した。実験 2：最適施用時期実験：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を解明する本実験を行った。

草原棲哺乳類の異なる移動戦略共存機構の解明と移動誘発ホルモン検出の試み

期間：2018 年 4 月－2020 年 3 月
代表者：伊藤健彦（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（伊藤健彦）・三重大学（飯島慈裕）・京都大学（木下こづえ）・明治大学（杉本太郎）・モンゴル科学アカデミー一般及び実験生物学研究所（B. Lkhagvasuren）・WWF モンゴル（B. Chimeddorj）・モンゴル獣医学研究所（B. Battsetseg）
研究費：科学研究費補助金　挑戦的研究（萌芽）
課題：モンゴルの草原地帯に生息する野生草食獣モウコガゼルの長距離移動にストレスホルモン濃度が関与している可能性を探る。リアルタイム衛星追跡により、遊動的な動物の位置を特定し、定期的な糞採集によるホルモン分析を実施する。

「遊動」を予測する：モンゴル草原の環境条件と野生草食獣の移動・活動量の関係

期間：2019 年 4 月－2021 年 3 月
代表者：伊藤健彦（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（伊藤健彦）・モンゴル科学アカデミー一般及び実験生物学研究所（B. Lkhagvasuren）・WWF モンゴル（B. Chimeddorj）
研究費：科学研究費補助金　新学術領域（公募研究）
課題：新学術領域「生物移動情報学」がめざす、動物のナビゲーション能力解明のため、モンゴルの草原地帯を遊動的に移動する野生草食獣モウコガゼルの移動と環境条件の関係を明らかにする。追跡個体では、位置データと同時に 3 軸加速度データも取得し、活動・行動パターンと移動フェーズや利用環境の関係も解析する。

耕作限界地のストレスに耐性をもつソルガムおよびコムギの遺伝的改良に関する遺伝育種研究

期間：2019 年 4 月－2022 年 3 月
代表者：辻本壽（鳥取大学乾燥地研究センター）
組織：鳥取大学乾燥地研究センター（辻本壽、ヤシル・ゴラフィ、山崎裕司）・スーダン農業研究機構（イザット・ecosystem in Mongolia and their impacts on wheat production in Sudan.

Ameliorative effects of brassinolide on growth, nutrition, antioxidase activity and yield of soybean under salinity stress

Period: Jul. 2019 – Dec. 2019
Leader: V. Otie (Calabar University)
Organization: Calabar University, Nigeria (V. Otie), ALRC Tottori University (P. An, H. Nakahara, Y. Shao)
Funding: Tottori University
Subject: Brassinolide (BR) is a kind of plant hormone. It has been reported to promote plant growth and induce stress tolerance in plants. However, its effects on plants under salinity stress has not been reported. This study investigated the promoting effect of BR on the growth of soybean. Experiment 1: Germination experiment: The BR was applied to the soybean seeds and germination rate was determined. Experiment 2: The optimal stage for BR application: This experiment was conducted in the greenhouse. Soybeans were grown in big pots and saline water were irrigated into the pots. The BR were applied to the plants at emergence, vegetative, flowering and yielding stages. The growth, physiological and biochemical parameters and yield of soybeans were measured.

Coexistence mechanism analysis of different migration strategies of grassland mammals and detection of hormones inducing migration

Period: Apr. 2018 - Mar. 2020
Leader: T. Ito (ALRC, Tottori University)
Organization: Tottori University (T. Ito), Mie University (Y. Iijima), Kyoto University (K. Kinoshita), Meiji University (T. Sugimoto), Institute of General and Experimental Biology, Mongolian Academy of Sciences (B. Lkhagvasuren), WWF Mongolia (B. Chimeddorj), Institute of Veterinary Medicine (B. Battsetseg)
Funding: KAKENHI (Grants-in-Aid for Challenging Research (Exploratory))
Subject: To examine the possibility of stress hormone effects on long-distance movements of Mongolian gazelles inhabiting Mongolia's grassland. Hormone analysis in regular intervals became feasible by collecting gazelles' fecal samples using real-time satellite tracking.

Prediction of nomadic movement: relationships between movement and activity of wild mammalian herbivores and environmental conditions in Mongolia's grassland

Period: Apr. 2019 - Mar. 2021
Leader: T. Ito (ALRC, Tottori University)
Organization: Tottori University (T. Ito), Institute of General and Experimental Biology, Mongolian Academy of Sciences (B. Lkhagvasuren), WWF Mongolia (B. Chimeddorj)
Funding: KAKENHI (Grants-in-Aid for Scientific Research on Innovative Areas)
Subject: The objective of the innovative area, "System Science of Bio-Navigation", is interdisciplinary understanding of animal navigation. We analyze relationships between environmental conditions and nomadic movements of Mongolian gazelles inhabiting Mongolia's grassland. We also analyze activity and behavioral patterns of gazelles by collecting 3-axis acceleration data to understand mechanisms of habitat selection and movement phase switching.

Gene mining of wild relatives to develop wheat varieties to adapt environment in agricultural marginal regions

Period: Apr. 2019‐Mar. 2022
Leader: H. Tsujimoto (ALRC, Tottori University)
Organization: Tottori University (H. Tsujimoto, Y. S. A. Gorafi,

タヘル）
研究費：鳥取大学
課題：ソルガムはアフリカの主要穀物であるが、生産の最大の脅威は干ばつである。また、コムギは需要増のためアフリカでの生産増が求められているが、高温、乾燥に加え塩害が問題となっている。そこで、本研究は、これらの問題を解決するため、ソルガムについては、アブシジン酸（ABA）感受性に着目して、新たな遺伝資源を選抜すること、コムギについては、野生種の遺伝資源を導入した集団（MSD）の中から、塩害に耐性の系統を選抜することを目的として行っている。

共生関係が成立するコムギおよびエンドファイトの遺伝子型の探索
期間：2017 年 4 月－2022 年 3 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、児玉基一朗）・ニュージーランド AgResearch（リチャード・ジョンソン、ウェイン・シンプソン）
研究費：科学研究費補助金　挑戦的研究（萌芽）、鳥取大学
課題：コムギ近縁野生種には内生菌が普通に見られストレス耐性に関与しているが、栽培コムギには存在しない。パンコムギに近縁種のエンドファイトを人工的に接種すると、植物体は矮性になり不稔性を示す。本研究では共生が成立し種子を生産するエンドファイト・コムギの組み合わせを調査した。その結果、野生種染色体をもつコムギ系統に、エンドファイトに感染しても正常な生育を示し、種子を形成して、次世代に菌を伝播できる組み合わせのあることを見いだした。

高温耐性コムギ系統の QTL 解析と選抜マーカーの開発
期間：2018 年 4 月－2021 年 3 月
代表者：辻本壽（鳥取大学乾燥地研究センター）
組織：鳥取大学乾燥地研究センター（辻本壽、ヤシル・ゴラフィ、妻鹿良亮、山崎裕司）・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）
研究費：科研費挑戦的研究（基盤 B）
課題：これまでの研究によって、申請者は複数の高温耐性コムギ系統を野生種（タルホコムギ）の遺伝資源を用いて開発した。本研究は、これら系統の高温耐性の遺伝様式を解明するため、耐性系統、通常系統およびそれらの雑種後代で作成する分離集団を用いて、関連染色体部位を QTL 解析法により解明し、QTL を識別するための分子選抜マーカーを作る。

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、妻鹿良亮、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：地球規模課題対応国際科学技術協力プログラム（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

Y. Yamasaki), Agricultural Research Corporation, Sudan (Izzat S. A. Tahir)
Funding: Tottori University
Subject: Sorghum is a major cereal in Africa, but the biggest threat to production is drought. In addition, there is a need to increase production of wheat in Africa due to increased demand, but high temperatures, dryness and salt damage are problems. In order to solve these problems, this study aims to select new genetic resources for sorghum, focusing on abscisic acid (ABA) susceptibility, and to select salt-tolerant strains of wheat from a population (MSD) introduced with wild-type genetic resources.

Exploration of wheat and endophyte genotypes that enables symbiotic relationship
Period: Apr. 2017 - Mar. 2022
Leader: H. Tsujimoto (ALRC, Tottori University)
Organization: Tottori University (H. Tsujimoto, M. Kodama), AgResearch, New Zealand (Richard Johnson, Wayne Simpson)
Funding: KAKENHI (Grants-in-Aid for Challenging Research (Exploratory)) and Tottori University
Subject: Endophyte is commonly found in wheat-related wild species and provides stress tolerance to the host plant. However endophyte is not found in cultivated wheat varieties. When bread wheat is artificially inoculated with the endophyte of the related wild species, the plant becomes dwarf and sterile. In this study, we investigated wheat-endophyte combination which enables normal symbiosis and seed production. As a result, we found wheat lines having a chromosome of wild species that shows normal plant growth even in the infection with an endophyte. This plant produced sees with endophyte and transferred it to the next generation.

QTL analysis of heat-stress tolerant wheat lines and production of selection markers
Period: April 2018-March 2021
Leader: H. Tsujimoto (ALRC, Tottori University)
Organization: Tottori University (H. Tsujimoto, Y. S. A. Gorafi, R. Mega, Y. Yamasaki), Utsunomiya University (M. Okamoto), Agricultural Research Corporation, Sudan (I. S. Tahir)
Funding: KAKENHI (Grants-in-Aid for Scientific Research (B))
Subject: In the previous studies, we produced several heat-tolerant wheat lines using genetic resources of wild species (Aegilops tauschii). In this study, in order to elucidate the genetic behavior of the tolerance, we will produce segregation population using the tolerant line and a normal cultivar. QTL analysis for the segregation population will reveal the relevant chromosome regions to the tolerance and enable to produce selection markers for heat stress tolerance.

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: June 2018-Jun. 2024
Leader: H. Tsujimoto (ALRC, Tottori University)
Organization: Tottori University (H. Tsujimoto, Y. S. A. Gorafi, R. Mega, 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: Science and Technology Research Partnership for Sustainable Development (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

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。

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－2021 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：鳥取大学乾燥地研究センター（藤巻晴行）・ナジャハ大学（Abdel Fattah El-Mallah）
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。

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－2022 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：鳥取大学乾燥地研究センター（藤巻晴行）・パレスチナ国立農業研究所（Z. Feras）
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。

作物成長の数値モデルと天気予報を利用した灌漑水量の決定
期間：2017 年 11 月－2020 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：鳥取大学乾燥地研究センター（藤巻晴行、Abd El Baki, H.M.）・スーダン農業研究機構（Fahad Alwagie）・ICARDA（V. Nangia）
研究費：限界地プロジェクト
課題：鳥取砂丘圃場、スーダンおよびモロッコ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。

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－2022 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：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

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.

Enhancing food security using water harvesting in West Bank of Palestine
Period: Apr. 2016 - May 2021
Leader: H. Fujimaki (ALRC, Tottori University)
Organization: Tottori University (H. Fujimaki), An-Najah University (Abdel Fattah El-Mallah)
Funding: Development of crop husbandry technology in rainfed 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.

Optimization of trigger suction for automated irrigation to Date Palm in Palestine
Period: Apr. 2018‐Mar. 2022
Leader: H. Fujimaki (ALRC, Tottori University)
Organization: Tottori University (H. Fujimaki), National Agricultural Research Center of Palestine (Z. Feras),
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.

Determination of irrigation depths using a numerical model of crop growth and quantitative weather forecast
Period: Nov. 2017 - May 2020
Leader: H. Fujimaki (ALRC, Tottori University)
Organization: Tottori University (H. Fujimaki, Abd El Baki, H.M.), Sudan Agricultural Research Cooperation (Fahad Alwagie), ICARDA (V. Nangia)
Funding: Development of crop husbandry technology in marginal rainfed environment using dryland plant resources
Subject: Field experiments were carried out in Sudan and Morocco to evaluate the effectiveness of a new scheme to determine irrigation depths using a numerical model of crop growth and quantitative weather forecast in terms of net income considering the price of water.

Development of next-generation Sustainable Land Management (SLM) framework to combat desertification
Period: April 2017- March 2022
Leader: A. Tsunekawa (ALRC, Tottori University)
Organization: Tottori University (A. Tsunekawa, H. Fujimaki, N. Haregeweyn, T. Taniguchi, N. Kobayashi and others), Shimane University (T. Masunaga and others), University of Tokyo (T. Okuro and others) Bahir Dar University (E. Adgo, D. Meshesha and others)
Funding: SATREPS
Subject: 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

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。

soil erosion and introducing crop-livestock production systems as well as linking such efforts to improving the livelihoods of local residents. Contribution to reduction of soil erosion, improvement of land productivity and local residents' livelihoods. Various SLM practices targeted to fight desertification have been implemented in many areas of the world, but their sustainability and effectiveness are being questioned. Hence this project aims to develop improved SLM technologies and approach that could address the major limitations of the currently implemented SLM practices and then to propose them to be used in the study sites and beyond such as to the entire Blue Nile Basin and other arid regions of the world that are experiencing similar problems.

（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

Mostafa Abdelwahed Noureldein Abdelrahman
（平成 30 年 4 月 1 日～令和 2 年 1 月 31 日）
日本学術振興会外国人特別研究員（一般）

Nasrein Mohamed Kamal Omer
（平成 31 年 4 月 1 日～令和 2 年 3 月 31 日）
スーダン農業研究機構バイオテクノロジー・バイオセーフティ研究センター・助教
私費

Eltayb Abdellatef Eltayb Farah
（平成 31 年 4 月 1 日～令和元年 9 月 30 日）
スーダン高等教育科学研究省国立研究センター　生物工学・遺伝子工学コミッション・助教
経費：松前国際友好財団

Miao Liu
（平成 31 年 4 月 1 日～平成 2 年 3 月 31 日）
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私費

Victoria Oko Otie
（令和元年 7 月 19 日～令和元年 12 月 17 日）
カラバ大学農林野外資源管理学院土壌科学学部・助手
鳥取大学乾燥地研究センター・海外研究者招聘型共同研究経費

Fen Zhang
（平成 31 年 1 月 4 日～令和元年 12 月 27 日）
蘭州大学・講師
私費

受託研究員

2019 年度 JICA 課題別研修「乾燥地における持続的農業のための土地・水資源の適正管理（A）」（令和元年 8 月 9 日）
アフガニスタン 2 名、イエメン 1 名、エジプト 1 名、ヨルダン 2 名、パレスチナ 1 名、ケニア 1 名、スーダン 1 名

研究生

Shuoshuo Liang
（令和元年 10 月 1 日～令和 2 年 3 月 31 日）中国
Setargie Tadesual Asamin
（令和元年 10 月 1 日～令和 2 年 9 月 30 日）エチオピア

(3) Foreign Researchers, Trainees and Research Students

Foreign Researchers

Mostafa Abdelwahed Noureldein Abdelrahman
(Apr. 1, 2018 - Jan. 31, 2020)
JSPS Postdoctoral Fellowship for Research in Japan (Standard)

Nasrein Mohamed Kamal Omer
(Apr. 1, 2019 - Mar. 31, 2020)
Assistant Professor, Biotechnology and Biosafety Research Center, Agriculture Research Corporation, Sudan
Private funds

Eltayb Abdellatef Eltayb Farah
(Apr. 1, 2019 - Sep. 30, 2019)
Assistant Researcher, Commission for Biotechnology and Genetic Engineering, National Center for Research, Ministry of Higher Education and Science Research
Funded by the Matsumae International Foundation

Miao Liu
(Apr. 1, 2019 - Mar. 31, 2020)
Postdoctoral Researcher, Institute of Geographic Science and Natural Resources Research, Chinese Academy of Sciences
Private funds

Victoria Oko Otie
(Jul. 19, 2019 - Dec. 17, 2019)
Senior Assistant Registrar, Department of Soil Science, Faculty of Agriculture, Forestry and Wildlife Resources Management, University of Calabar, Nigeria
Funded by Guest Research Associate for joint Research Program, Arid Land Research Center, Tottori University

Fen Zhang
(Jan. 4, 2019 - Dec. 27, 2019)
Lecturer, Lanzhou University
Private fund

Visiting Trainees

JICA Group Training Course 2019 “Appropriate Management of Land and Water Resources for Sustainable Agriculture in Arid/Semi-arid Regions (A)” (Aug. 9, 2019)
2 Afghanistan, 1 Yemeni, 1 Egyptian, 2 Jordanian, 1 Palestinian, 1 Kenyan, 1 Sudanese

Research Students

Shuoshuo Liang
(Oct. 1, 2019 - Mar. 31, 2020) China
Setargie Tadesual Asamin
(Oct. 1, 2019 - Sep. 30, 2020) Ethiopia