

Republic of Sudan  
Agricultural Research Corporation (ARC)

REPUBLIC OF SUDAN  
PROJECT FOR THE 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

Project Completion Report

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Japan International Cooperation Agency (JICA)

Tottori University

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## **I. Basic Information of the Project**

### **1. Country**

The Republic of the Sudan

### **2. Title of the Project**

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

### **3. Duration of the Project (Planned and Actual)**

Planned: November 2019 - November 2024

Actual: November 2019 - April 2025

The Agricultural Research Corporation (ARC) and Tottori University signed a Collaborative Research Agreement on March, 2019, to conduct research on the project in accordance with the R/D signed between the JICA and ARC. The SATREPS was then scheduled to start in April, 2019. However, due to the security situation during the People's Revolution, the deployment of experts from Japan to Sudan was delayed until November 2019, when the project was scheduled to commence. The COVID-19 pandemic in 2020 and the political turmoil in October 2021 resulted in the suspension of the project activities by JICA, including experts' visits to Sudan, until February 2022. This affected the progress of some project activities. Later, the armed conflict between the paramilitary Rapid Support Force (RSF) and the Sudan Army Force (SAF), which started in Khartoum in April 2023 and spread to Gezira in December 2023, substantially affected most of the activities, especially the rehabilitation of the molecular and speed breeding facilities and laboratory equipment procurement process. Subsequently, both the Japanese and Sudanese sites requested the project extension up to March 31, 2025, which was approved during the 5th JCC Meeting in November, 2023.

### **4. Background (from Record of Discussions (R/D))**

Wheat has a long history in Sudan, dating back to a thousand year BC. The Nubians in northern Sudan knew how to grow wheat and used it as their main food. The wheat cultivation in Sudan remained confined to small areas north of the latitude 17° N using primitive methods and traditional varieties. As a result of steady population growth, waves of urban migration, and changing dietary patterns, access to bread became an

inevitable extension of people's suffering due to its scarcity or unaffordable prices, which were beyond the reach of people with limited incomes.

Until the Second World War, all attempts to expand wheat cultivation south of Khartoum failed due to the lack of adapted varieties and suitable technologies. Since the 1960s, the ARC has developed more than 70 different agricultural technologies, including more than thirty wheat varieties suitable for the heat-stress environment in Sudan. This led to the expansion of wheat cultivation in areas that were classified as unsuitable environments, such as Gezira, New Halfa, White Nile, and others.

Despite this expansion of wheat cultivation, the biggest challenge has been the substantial increase in consumption. For example, the annual rate of increase in wheat production from 1960 to 2016 was about 9,400 tons annually, but the annual rate of increase in consumption during the same period exceeded about 42,000 tons, i.e. the annual rate of increase in consumption is equivalent to more than 4 times the annual rate of increase in production. In order to bridge the gap between wheat production and consumption, it has been necessary to import large quantities of wheat; for example, 2.5 million tons were imported in 2014, with a value of more than one billion dollars. To meet this challenge, and to bridge the wide gap between production and consumption in the face of climate change, which is expected to exacerbate such a challenge, it was necessary to think of innovative ways and methods to increase wheat productivity by providing appropriate technologies that can contribute positively to mitigating the adverse effects and risks that may result from climate change, based on agricultural research for development, taking into account the optimal use of natural resources. The SATREPS Wheat Project, "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 launched to achieve these and other objectives.

The objectives of the SATREPS Wheat Project were: 1) improving the nutritional value and accelerating the process of improving wheat to adapt to climate changes through the application of modern technologies and identifying the mechanisms that lead to adapting wheat to abiotic stresses, 2) developing alternative scenarios and models for wheat production in Sudan that are appropriate to the future climate changes and use them to determine priorities and develop strategies for improving wheat production and providing information for future wheat-breeding strategies, 3) capacity building and development and dissemination of agricultural technologies and innovations by strengthening research facilities and enhancing capacities of all stakeholders along the wheat value chain, and implementing seed production plans.

Based on the minutes of the meetings on the Detailed Planning Survey for the SATREPS Wheat Project signed on 10 September 2018 between ARC (the Counterpart) and the Japan International Cooperation Agency (JICA), JICA held a series of discussions with the Counterpart and relevant organizations to develop a detailed plan of the Project.

The record of discussions (R/D) established a mutual agreement for its implementation by both parties and agreed on the detailed plan of the Project, to be implemented within the framework of the Note Verbales exchanged between the Government of Japan and the Government of Sudan on 23 October 2018. The Counterpart took responsibility for implementing the project in cooperation with JICA, coordinating with other relevant organizations, and ensuring that the project's self-reliant operation will be sustained during and after the implementation period to contribute toward Sudan's social and economic development.

## **5. Overall Goal and Project Purpose (from Record of Discussions (R/D))**

**Overall Goal:** Climate change resilient and nutritious candidate wheat varieties are newly developed by ARC.

**Project Purpose:** Climate change resilient and nutritious wheat germplasm and the appropriate wheat production method are developed, and that information is shared with the people concerned with the wheat production.

## **6. Implementing Agency**

Sudan: Agricultural Research Corporation (ARC) and Sudan Meteorological Authority (SMA).

Japan: Tottori University (TU) and Utsunomiya University (UU).

# **II. Results of the Project**

## **1. Results of the Project**

### **1-1 Input by the Japanese side (Planned and Actual)**

#### **1-1.1 Allocation of the Japanese experts.**

Although the original plan to despatch the Japanese experts was delayed due to the security situation during the People Revolution, following the project's kick-off, the

first batch of the Japanese experts visited Sudan in November 2019. The Japanese side assigned the following experts:

- Prof. Hisashi Tsujimoto (Output 1, Breeding group)
- Dr. Hiroyuki Tanaka (Output 2, Quality group)
- Prof. Kinya Akashi (Output 3, Physiology group)
- Prof. Mitsuru Tsubo (Output 4, Climate change group)
- Dr. Yasir Sereg Alnor Gorafi (Output 5, Capacity building group)
- Dr. Takafumi Konaka (Project Coordinator)
- Ms. Sachiko Shah (Project Coordinator)

The full list of the experts dispatched from Japan to Sudan is shown in **Annex 1-1.1**.

### **1-1.2 Machinery and Vehicle procurement and maintenance**

The full list of the machinery and vehicles procured by the project is shown in **Annex 1-1.2**.

- Two vehicles were purchased and delivered.
- Experimental equipment, such as seed drills, weather stations, instruments for measuring plant and crop physiological traits, and a combine harvester, have been purchased and delivered.
- A glass house as a speed breeding facility was purchased and delivered to ARC.
- The coordinator's office equipment was purchased.
- One driver and one secretary have been employed.

### **1-1.3 Establish molecular and speed breeding facility**

- The container house (warehouse) was constructed.
- Tottori University consigned ARC through a contract to perform and manage all the project activities, including renovating the molecular and speed breeding facility.
- Renovation of the molecular and speed breeding facility, including assembly of the glass house and equipment purchase, has been suspended since the conflict spread to Gezira State in December 2023.
- Due to the security situation in Gezira State, the Project decided at the 6th JCC meeting on August 6, 2024, to terminate the contract for the renovation of the laboratory and other related activities and to implement an alternative plan to purchase seeds of the heat-tolerant wheat varieties and distribute them to seed producers and farmers at the IP sites, and other equipment for the research station in the safe zones of the country.

#### **1-1.4 Equipment for molecular and speed breeding**

- The first batch of the molecular breeding equipment was purchased and most of them were delivered to ARC.
- The purchase and delivery of the second batch is completed.

The full list of the equipment for molecular and speed breeding laboratory procured by the project is shown in **Annex 1-1.3**.

#### **1-1.5. Twenty-five (25) Short and medium-term specialized trainings in Japan and Sudan for Project counterparts and other IP stakeholders**

- Short-term training for five researchers from ARC was conducted in Japan.
- Fifteen training courses were conducted in Sudan for different stakeholders along the wheat value chain. A total of 498 farmers, researchers, extensionists, engineers, and seed producers in the public and private sectors and housewives were trained. The names, locations, dates, and participant numbers of the training workshops and courses conducted by the project in Sudan are shown in **Annex 1-1.4**.

#### **1-1.6 Local cost for different activities of the Project**

The project allocated a total of 53,318,375 Japanese Yen (JPY) to cover the costs of the project's local activities. In 2019, due to the delay in dispatching the project coordinator because of the security situation, Tottori University transferred a total of 1,650,000 JPY to ARC to be used for seed production. The rest of the budget was managed by the JICA coordinators for salaries, running costs of the vehicles, conducting training courses, production and purchasing seeds, provision of some office supplies and stationeries, etc.

### **1-2 Input by the Sudan side (Planned and Actual)**

#### **1-2.1. Allocation of the counterpart personnel**

All the necessary personnel were allocated, including researchers, technicians, accountants, and other support staff. In particular, the project assigned five people as the counterpart group leaders for the five project groups. The project also set up the Joint Coordination Committee, which consisted of all relevant people from ARC, SMA, Ministry of Agriculture and Forestry, Ministry of Finance and Economic Planning, and the Japanese side from JICA, JST, and the Japanese Agency for International Cooperation. A list of the personnel involved in the project implementation from all stakeholders at ARC research stations, Sudan Meteorological Authority, Ministry of

Agriculture and Forestry, National Wheat Production Project, National Seed Administration, etc., is shown in **Annexes 1-2.1, 1-2.2 and 1-2.3.**

### **1-2.2. Provision of offices and necessary space for the Japanese experts**

- The ARC provided office space for the coordinator, as well as laboratory and experimental fields at the main campus of ARC (Wad Medani) and all other regional experimental stations.

### **1-2.3. Local cost (salary of the personnel, utilization of existing machinery and equipment, maintenance and running cost of the machinery)**

- All facilities related to the implementation of the project activities were made available at different research stations in the target areas, including field machinery. Equipment and their maintenance.
- The salaries and other benefits of the personnel involved in the project were regularly paid.
- A detailed local project budget was prepared, submitted to the Ministry of Finance and Economic Planning, and approved.
- The budget for the first three years was approved and partially released.
- Due to the current army conflict situation, the local components for 2023 and 2024 were not released.

### **1-2.4. Provision of postgraduate degree assistantships in local universities**

- The project provided partial support for some postgraduate students to facilitate their field experiments. However, due to the suspension of the registration of new postgraduate students in the Sudan Academy of Science, with which ARC is affiliated, no assistance was provided for the degree assistantship.

### **1-2.5. Provision of experimental farms and laboratory space at all sites**

- ARC provided all necessary experimental farms at all project sites in Gezira, New Halfa, River Nile, and Northern States.
- Similarly, laboratory spaces were provided at all associated research stations in addition to the provision of the space for container house and molecular lab construction at Gezira Research Station, Wad Medani.

### 1-3 Activities (Planned and Actual)

#### 1-3.1. Breeding group (Output 1):

The activities of the breeding group can be summarized as follows:

- Evaluated the wheat germplasm in multi-environment trials in Sudan and Japan and identified several heat- and drought-tolerant lines.
- Identified agronomically important quantitative trait loci (QTLs) and marker-trait associations (MTAs) and established a molecular breeding platform to develop new wheat cultivars tolerant to heat or drought using the newly identified QTLs.
- Produced the early-generation seeds (breeder, pre-basic, and basic seeds) of the commercial and recently released wheat cultivars, which are used to produce certified seeds to be disseminated to farmers.

The detailed activities and status of achievements for the breeding group are shown in **Table 1-3.1**.

**Table 1-3.1.** The activities and status of achievements for the breeding group (Output 1)

Activities	Status/Achievement	% achieved
1.1. Multi-location evaluation for selection and confirmation of the desired lines	1.1. Multilocation evaluations for four seasons for different sets of genotypes were conducted at Gezira, Kassala, River Nile, and Northern states. The 1st and 2nd Elite SATREPS Yield Trials have been sent to Nigeria, DRC, Uganda, and Mauritania. Three promising lines were selected in Nigeria and are being tested in multi-location trials.	100
1.2. Development of recombinant inbred lines (RILs) for each of the desired traits, genotyping, and QTLs identification	1.2. Seven RILs populations were developed, genotyped, and evaluated under different conditions, and more than 193 QTLs were identified, of which 39 were associated with heat stress tolerance.	100
1.3. Development of PCR markers for the identified QTLs	1.3. Analysis was conducted, and markers were designed and tested for three QTLs associated with grain yield, heat tolerance, and seed size.	100
1.4. QTLs pyramiding in the Background of N61 and	1.4. Desirable genes and alleles for biomass, harvest index, seed size, etc., pyramided in the	100

Sudanese cultivar	background of elite genotypes, including Norin 61, Miki 3, and the Sudanese cultivars Imam, Bohaine, and an elite durum wheat line (ADWYT216).	
1.5. Initiate and establish MAS to transfer the desired QTLs to Sudanese wheat genetic background	1.5. Marker-assisted selection (MAS) was initiated, and the transfer of desirable genes and alleles to elite genotypes was successfully applied.	100
1.6. New lines registration	1.6. The MSD population has been described and registered, and 400 MSD lines were deposited in the gene bank of Wheat Bio Resource Project, Kyoto University.	100
1.7. Produce officially categorized seeds	1.7. Breeder, pre-basic, and basic seeds of nine heat-tolerant/disease-resistant wheat varieties were produced and made available for seed producer partners.	100
1.8. Establish future breeding strategies based on climate analysis output	1.8. Climatic and crop data were analyzed, technology registration was prepared, and future breeding strategies were proposed. The climate and crop data analysis indicated that, unlike the current recommendation, each variety's sowing time should be based on the genotype x environment x management (G x E x M) interactions. For future sustainable wheat production in Sudan, specific wheat varieties adapted to each production region should be developed considering the G x E x M interaction	100
1.9. Selection of plant hormone abscisic acid (ABA) hyper-sensitive line for drought tolerance and QTL analysis	1.9. ABA-hypersensitive lines, which exhibit drought-tolerant traits such as stomatal closure and water conservation, were isolated. Potential lines have been selected and crossed to develop the QTL mapping population. Candidate QTLs were successfully identified.	100

### 1-3.2. Quality group (Output 2):

The activities of the quality group can be summarized as follows:

- Studied seed traits (shape, weight, hardness), protein content, SDS-sedimentation volume, amylose content, zinc content, mixing test, and bread-making test to evaluate the end-use quality and nutritional values. Studied the end-use quality and nutritional value in the developed germplasm and identified several potential lines that combine both tolerance and enhanced end-use quality.
- Identified new QTLs and MTAs that control heat tolerance and enhance end-use quality.

The detailed activities and status of achievements for the quality group are shown in **Table 1-3.2**.

**Table 1-3.2.** The activities and status of achievements for quality group

Activities	Status/Achievement	% achieved
2.1. Examine the seed characters and quality parameters of lines grown under heat and stress conditions	2.1. Seed characters and quality parameters examined under heat stress and promising lines identified	100
2.2. Analysis of protein content and bread-making quality	2.2. The protein content and bread-making quality were analyzed, and two elite lines with better quality identified	100
2.3. Analysis of the mineral contents and nutritional value	2.3. The mineral contents and nutritional value of the multiple synthetic derivatives (MSD) lines studied under heat stress, and two promising lines with high mineral content were identified.	100
2.4. Cross the lines that possess the desired traits with the N61 and Sudanese cultivars to identify the QTLs and develop molecular markers for MAS	2.4. Crosses and backcrosses were made between lines with desirable quality traits, and N61 and some Sudanese cultivars and QTLs for MAS were identified.	100
2.5. Introduce the high-quality gene ( <i>Glu-D1d</i> ) to the genetic background of a Sudanese cultivar (Bohaine) that maintains high bread-making quality even under high temperature	2.5. The high-quality gene ( <i>Glu-D1d</i> ) was introduced to the background of Bohaine (a Sudanese wheat cultivar that maintains high bread-making quality under high temperatures).	100

### 1-3.3. Physiology group (Output 3):

The activities of the physiology group can be summarized as follows:

- Explored the physiological mechanism of heat and drought tolerance in the new germplasm using metabolomics and transcriptomics.
- Identified the key physiological and biochemical factors underlying heat and drought adaptation.
- Established a new analysis platform to understand crop response under stress conditions.

The detailed activities and status of achievements for the physiology group are shown in **Table 1-3.3.**

**Table 1-3.3.** The activities and status of achievements for the physiology group

Activities	Status/Achievement	% achieved
3.1. Detailed physiological evaluation for the tolerant and sensitive lines in the field and growth chambers	3.1. Physiology and agronomic traits of tolerant and sensitive wheat lines were evaluated in the field and growth chamber. The tolerant lines maintained their photosynthetic activity under heat stress. Exposure to heat stress had different impacts on various agronomic traits (yield, thousand kernel weight, biomass, grain number, etc.) in different lines.	100
3.2. Analyse metabolites produced specifically in tolerant lines under stressed conditions and identify the metabolites to reveal the mechanism of the tolerance to be used for selection	3.2. The metabolic profile of the representative tolerant lines was analyzed. The level of the amino acid beta-alanine showed a negative correlation with several agronomic traits, such as yield. In contrast, other intermediate amino acids positively correlated with the yield-related parameters. Databases on the metabolome behaviors were constructed.	100
3.3. Identify genes usable for selection from the profile of tolerant	3.3. Transcriptome data of the representative tolerant lines under heat	100

lines mRNA	stress were taken, and their unique mRNA profiles were analyzed. Molecular mechanisms for heat stress tolerance were identified through (i) metabolic regulation of a unique set of tolerance-related amino acids and (ii) alteration of cell wall components. Ten sets of omics data for the heat stress responses were constructed.	
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### 1-3.4. Climate change group (Output 4):

The activities of the climate change group can be summarized as follows:

- Analyzed Sudan's past and future climate for 48 years (crop seasons) from 1970/71 to 2017/18 and proposed the necessary measures to avoid climate change risk.
- Conducted several field studies to develop innovations to mitigate the climate change risk.

The detailed activities and status of achievements for the climate change group are shown in **Table 1-3.4**.

**Table 1-3.4.** The activities and status of achievements for the climate change group

Activities	Status/Achievement	% achieved
4.1. Predict the climate of Sudan in 2050 from the past and present climate observation and rising CO <sub>2</sub> concentration	4.1. Sudan's past and present climatic data for 48 years (crop seasons) from 1970/71 to 2017/18 were analyzed, and the necessary measures to avoid the risk of climate change climate change risk were proposed.	100
4.2. Develop crop model for wheat production in different climate scenarios	4.2. A prototype model for wheat production under different climate scenarios has been developed. The model simulation showed a reduction in domestic production share from 16% under the current climate to 4.5% under a pessimistic scenario and 12.2% under an optimistic scenario by 2050, indicating significant	100

	annual yield improvements required to meet future demand.	
4.4. Examine the response of the developed germplasm to the future climate scenarios	4.4. The response of the developed germplasm to the future climate scenarios was examined under heat and drought conditions. Micrometeorological observations in irrigated fields confirmed that Imam, a later-maturing cultivar with a semi-prostrate growth habit, had a larger canopy temperature depression than Bohaine, a fast-maturing cultivar with a fully erect growth habit. In addition, model simulation for yield comparison between common cultivars under the future climate scenarios showed that Imam is more tolerant to high temperatures than Debeira. Furthermore, the field experiments conducted under drought conditions showed that some MSD lines performed better than the widely planted cultivar (Imam). These indicate that the selected MSD lines are prominent genotypes for better performance under future climate change.	100
4.5. Develop climate-smart agricultural crop production technologies (CSA)	4.5. The early warning system, a crop yield outlook system based on seasonal climate forecasts, has been designed using a statistical model approach, i.e., multiple regression. The models only with temperature data as predictors can effectively predict yield anomalies, but other factors influence their accuracy, so it is recommended that additional factors, like irrigation practices, should be incorporated to enhance model precision.	80

	Climate-smart agricultural crop production technologies, such as varieties and their interaction with crop management, have been developed and await official approval.	
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### 1-3.5. Capacity building group (Output 5):

The activities of the capacity-building group can be summarized as follows:

- Conducted a baseline survey in Sudan's major wheat production states and identified the intervention areas. Significant differences were found in the productivity of technological options adopters compared to non-adopters. Access to quality seed, financial credit, and extension services were found to be the most critical determinants of adopting improved technologies.
- Conducted long-term training for PhD degrees in Japan (7 students) and short-term training for researchers in Japan (5 trainees) (**Annex 1-2.3**).
- Conducted 15 training workshops and courses for a total of 498 farmers, extensionists, researchers, technicians, and seed producers in the public and private sectors (**Annex 1-1.4**).
- Established six innovation platforms (IPs) for technology validation and dissemination in the main wheat production states, Gezira (2 IPs), New Halfa (2 IPs), River Nile (1 IP), and Northern State (1 IP). The project adopted the innovation platform concept, which was first introduced earlier in Sudan. In brief, each IP operates through facilitators from research stations, extension services, farmers, and other stakeholders. Work plans were made before the cropping season. Before the next cropping season, review and planning meetings were held at each IP site to discuss what has been achieved, any challenges encountered during the implementation, and how lessons learned can be applied for the next season. The IPs allow different stakeholders to interact with each other to understand each other better, learn and develop shared priorities, define roles, and agree on joint actions and work plans toward the realization of the agricultural revival and development.
- In partnership with public and private sectors (PPP), certified seeds of the popular and recently released wheat cultivars were produced and disseminated to farmers

in the IPs sites. Eight heat-tolerant wheat varieties were used for seed multiplication, which had been registered before the start of the project. Some of the varieties were tested for the presence of disease-resistance genes in collaboration with Tottori University; however, these varieties were developed by Sudanese breeders at ARC. The quantity of seed produced through the project in partnership with the public and private sector increased from 41.7 tons in season 2019/20 to 5,411 tons in season 2021/2022 and more than 13,600 tons in season 2022/23. The project, with its partners, contributed only 0.12% to the total national seed production in the first season (2019/20); however, the contribution increased to 18.7% in season 2021/2022 and reached more than 34% in season 2022/23. Even under insecure conditions in 2023/24, the project, with its partners, produced more than 10,000 tons of seed for the commercial and recently released varieties.

- Provided training and technical backstopping to the farmers and other stakeholders in the IPs through the production of booklets, manuals, and pamphlets for wheat production technological options (**Annexes 1-3.1 and 1-3.2**), training workshops, farmers' field schools, technology validation and dissemination plots, and technical symposia, field and harvest days, and several TV and radio training programs. A total of 459 participants attended 14 training workshops and courses. Over 1350 people participated in 18 field and harvest days at IP sites.
- In addition, five innovative drama-based episodes were produced and broadcasted via different media, including YouTube, TV, public transportation buses and trains, WhatsApp, Facebook, Twitter, etc. Over 19,245 views have been recorded on the YouTube channel for these episodes so far (<https://www.youtube.com/@-satrepwheatprojectsudan-5600/videos>). So far, more than 2,560 farmers, researchers, agricultural engineers, technicians, extensionists, seed producers, input providers, etc., directly or indirectly benefited from the activities of the project at different IP sites. A direct comparison between the participating (PF) and non-participating farmers (NPF) in the activities of the project in 2023/24 showed an increase in the productivity of PF by 44.6%

compared to NPF. For instance, farmers' feedback in the annual review and planting meetings and the field days indicated a considerable increase in areas and productivity of wheat at IP sites. For example, an increase in average productivity within Wad Hussain IP in Gezira from 1.9 tons/ha to 3.3 tons/ha was reported.

The detailed activities and status of achievements for the capacity-building group are shown in **Table 1-3.5**.

**Table 1-3.5.** The activities and status of achievements for capacity building group

Activities	Status/Achievement	% achieved
5.1. Conduct a baseline survey to determine the Project intervention areas	5.1. The baseline surveys were conducted, key factors influencing the adoption of improved technologies were identified, and the results were published.	100
5.2. Conduct a monitoring and impact assessment studies	5.2. Annual review, monitoring, and planning meetings were regularly conducted. An impact assessment survey could be conducted in the future if the security situation allows.	100
5.3. Produce officially categorized seeds	5.3. Certified seeds for IPs produced in partnerships with private and public seed producers.	100
5.4. Establish Project website multimedia content for technology dissemination, communication, and awareness among the stakeholders	5.4. The project website was established and regularly updated. Multimedia content, including booklets and YouTube channels, has been published.	100
5.5. Establish innovation platforms (IP) for all stakeholders along the wheat value chain	5.5. Six IPs were established in four wheat-producing areas, operationalized, and various activities related to the dissemination of improved technologies were conducted.	100
5.6. Conduct degree and non-degree trainings in Japan and Sudan	5.6. Six students obtained their PhDs, and one is in progress. Five short-term trainees were trained at Tottori University (a	100

	one-month training course).	
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## 2. Achievements of the Project

### 2-1 Outputs and indicators (Target values and actual values achieved at completion)

In addition to what is practiced in most wheat research programs worldwide, including Sudan, the research work in this project relied on the use of genetic resources with wide genetic diversity derived from wild relatives of wheat to overcome the problem of narrow genetic diversity and increase the chances of success. All the specialized research groups in Japan and Sudan worked in an integrated way. The target and actual achievements at the completion of the SATREPS Wheat Project are shown in **Table 2-1**.

**Table 2-1.** Target and actual values achieved at the completion of the SATREPS Wheat Project

Narrative Summary	Objectively Verifiable Indicators	Achievements
1. Heat, water deficit tolerant, and nutrient-use efficient wheat lines are developed using modern technologies	1. Ten (10) elite wheat lines with enhanced tolerance to heat and water deficit stress with better nutritional value and more efficient resource utilization are made available	1.1. At least six (6) heat-tolerant lines, five (5) water-deficit stress-tolerant lines, five (5) lines with improved quality and nutritional value, and three (3) lines with enhanced nutrient use efficiency have been made available. 1.2. A total of twelve (12) papers were published in refereed journals
2. Nutritional value and end-use quality of wheat are enhanced under the heat-stressed environments of Sudan	2. Germplasm with enhanced nutritional value is identified	2.1. Germplasm with enhanced nutritional value in the background of some Sudanese cultivars were made available 2.2. A total of five (5) papers were published in refereed journals
3. Mechanisms behind heat and water-deficit stress tolerance, and better utilization of	3.1. At least two (2) mechanisms behind heat and water-deficit stress tolerance, and better	3.1. Two (2) tolerant mechanisms, one for beta-alanine-related grain filling extension under heat, and the other for cell wall dynamics under

<p>nutrients are clarified, and information is made available to be utilized in future breeding strategies</p>	<p>utilization of nutrients are clarified, and information is made available 3.2. Data-server for the analysis of at least ten (10) sets of omics data are made available</p>	<p>heat, were found. 3.2. More than ten (10) sets of omics data were obtained, and more than half were released to the public. 3.3. Six (6) papers published in refereed journals.</p>
<p>4.1. Wheat production scenarios in Sudan for future climate change are developed 4.2. Sustainable, environmentally friendly, and appropriate wheat production technologies are developed</p>	<p>4.1. Alternative scenarios and models for wheat production are made available 4.2. Two wheat production technologies are developed</p>	<p>4.1. Future climate of Sudan predicted for the year 2050 (2046–2065). A prototype model has been developed. An early warning system has been designed: a statistical model of yield prediction based on seasonal forecasts as input data. The system can be used for pre-season cultivar selection and sowing date decisions. 4.2. Two (2) wheat production technologies were developed 4.3. Six (6) papers published in refereed journals.</p>
<p>5. Capacity of researchers and farmers are strengthened and interaction among different stakeholders are enhanced for increased and sustainable wheat production</p>	<p>5.1. Five (5) IPs are established 5.2. Five hundred (500) farmers in total are directly involved in IP activities 5.3. Productivity of directly participating farmers increases by 20% 5.4. Fifteen thousand (15,000) people view the contents of the website and the multimedia provided by the Project 5.5. Six (6) MSc or PhD degrees are obtained</p>	<p>5.1. Six (6) IPs were established and operationalized. 5.2. More than 1,500 farmers directly involved and benefited from the activities within the IPs. 5.3. The productivity of participating farmers increased by 35-44 % 5.4. More than 19,000 people viewed the content of the project site on YouTube alone. 5.5. Six (6) students obtained their PhD.</p>

## 2-2 Project Purpose and Indicators

(Target values and actual values achieved at completion)

### 2-2.1 The seminar on the results of the Project is organized

- The final project symposium was held on February 13, 2025, at Tottori University in Japan. Seven people from ARC, MTA, and the Sudan Seed Producer Association, representing the project partners, attended the symposium. The Book of Extended Abstracts of the Final Symposium is shown in **Annex 2-2.4**.

### 2-2.2 At least three (3) reports related to the Project are published by the international journals

- Forty-one scientific papers and six movies have been published in high-impact refereed journals. The full list of published papers in refereed journals is shown in **Annex 2-1.1**.
- One hundred fourteen oral and poster presentations were made at national, regional, and international conferences, workshops, and meetings. The full list of oral and poster presentations at national, regional, and international conferences, workshops, and meetings is shown in **Annex 2-2.2**.
- Nine awards were given from various organizations, and 36 articles were released by news paper and TV/radio programs, as shown in **Annex 2-2.3** and **2-2.5**.

## 3. History of PDM Modification

Following the 4<sup>th</sup> JCC on 26 October 2022, the following modifications were made to the PDM:

1. Indicators for Overall Goal and Output 3.1 amended.
2. Output 5.6. was modified to “Conduct degree and non-degree training in Japan and Sudan.”
3. Objectively verifiable indicators 5.3 was modified to “Six (6) MSc or PhD degrees are obtained.”
4. The implementation of some activities has been extended.
5. Some activities and verifiable indicators were modified, and PDM and PO were finalized at the 4<sup>th</sup> JCC meeting.

Following the 5<sup>th</sup> JCC on 1<sup>st</sup> November 2023, the following modifications were made to the PDM:

6. Revised PO was proposed and shown at the 5<sup>th</sup> JCC due to the extension of the project period.

Copies of all versions of the PDM and PO of the project are shown in **Annexes 3.1-3.6**.

## **4. Others**

### **4-1 Results of Environmental and Social Considerations**

Not applicable

### **4-2 Results of Considerations on Gender/Poverty Reduction.**

The project attempted to mainstream gender into some gender-related activities in Sudan. For instance, 30-50% of participants in the training workshops and courses were women and youth. In addition, a training course on baking and confectionery skills development was organized for 50 housewives.

The project's intervention in disseminating improved technologies, including high-quality seeds, resulted in increased yields for farmers, thereby contributing to improved livelihoods and, ultimately, to poverty reduction.

## **III. Results of Joint Review**

### **1. Results of Review based on DAC Evaluation Criteria**

#### **1-1. Relevance**

The relevance of the Project is evaluated as extremely high.

Sudan, with its natural resources, is considered one of the countries that can help ensure global food security, with 60-80% of the working population depending on agriculture for income and livelihood. Arable land accounts for about one-third of the country's land area, of which only 21% is currently cultivated. Agriculture, when successful, can drive economic development by creating jobs, making rural areas more appealing, and reducing migration.

Wheat is one of the most important crops worldwide and the most widely grown cereal. Wheat, sorghum, and millet provide nearly half of the daily calories in the Sudanese diet. Historically, wheat was the staple food only in the north, but it is now a key strategic food crop due to increased consumption resulting from population growth and urbanization. Wheat production doubled in the 2000s compared to the 1970s, but imports increased from 155,000 to 1.2 million tons. In 2013, Sudan spent over US\$780

million to import 2.2 million MT of wheat. Achieving self-sufficiency means increasing production and productivity.

For these reasons, wheat production needs to be increased from the food security perspective and to alleviate foreign currency shortages. In all medium- and long-term economic reforms, such as the Five-Year Plan for Economic Reform (2015-2019), the Sudanese government has positioned wheat as the "most important strategic food crop". The economic reform program of Sudan aimed to increase wheat production by 2.7 million tons and productivity by 0.9 tons per hectare over five years. In 2020, wheat was again prioritized by the government, and measures were taken to announce encouraging prices for locally produced wheat before the planting season, and the Agricultural Bank of Sudan was asked to purchase all locally produced wheat from farmers.

Following the war in Ukraine and the related food security challenges, wheat was again recognized by the government and the African Development Bank as the top priority crop in 2022. As a result, an emergency project for wheat production was launched by the African Development Bank and implemented by the World Food Program.

## **1-2. Coherence**

The coherence of the Project is evaluated as very high.

This project was built on the long collaboration between ARC and Tottori University, dating back nearly 30 years. However, there was no direct collaboration (complementarity, harmonization, and coordination) with other JICA projects. The preliminary results of the previous collaborative projects between ARC and TU clearly laid the foundation for the development of the current project. In addition, the project also established one of its innovation platforms in one of the areas where JICA had an intervention in the River Nile State (Aliab and Kityab areas).

On the other hand, the project had concrete cooperation (complementarity, harmonization, and coordination) with other projects implemented by Japan or other development partners, such as the Marginal Agriculture Project in collaboration with Tottori University, the TAAT (Technologies for African Agriculture Transformation) Project funded by the African Development Bank, the Sudan Emergency Wheat Production Project implemented by the World Food Program, the Food Security in Arab Countries Project implemented by ICARDA (International Center for Agricultural Research in the Dry Areas), etc.

For successful implementation and efficient use of resources, the project established mutual relationships and worked in harmony and synergy with these projects.

For instance, all training workshops and courses, technical symposia, technical backstopping field visits, field and harvest days, etc., were jointly organized for the maximum efficient use of the limited resources available during the conflict.

The project was consistent with some global goals for sustainable development especially SDG2.

### **1-3. Effectiveness**

The effectiveness of the Project is evaluated as extremely high.

Although the project was faced with enormous challenges, such as the People's Revolution, COVID-19, political turmoil, and armed conflict, coupled with financial and political instability, the project achieved all of its purposes and, in some cases, by more than 100%. For instance, the project was able to establish and operate six innovation platforms instead of the planned five. The project also produced more than 30% of the available certified seeds in partnership with the private and public sectors, resulting in yield increases of more than 30-44% in some IP sites in Gezira State (2022/23) and Northern State (2023/24), compared to 20% indicated in the project document. Additionally, the project produced five innovative drama-based episodes that were broadcast through various media, including YouTube, TV, public transportation buses and trains, WhatsApp, Facebook, Twitter, etc. To date, these episodes have received more than 19,300 views on the YouTube channel, exceeding the target of 15,000 viewers. So far, more than 2,560 farmers, researchers, agricultural engineers, technicians, extension workers, seed producers, input providers, etc., have directly or indirectly benefited from the activities of the project at different IP sites. In synergy with other projects, a total of 14 training workshops and courses were organized and more than 450 participants attended.

### **1-4. Efficiency**

The results of the activities have led to effective achievement, and the project purpose has been fully achieved or exceeded the plan.

Due to the occurrence of many obstacles, including a civil revolution, the COVID-19 pandemic, political turmoil, and war, the project period was extended by five months. Due to the conflict, the project implementation base in Wad Medani became a war zone, and the staff had to be evacuated to other safe zones to continue the project activities. Through weekly online meetings held between Sudan and Japan, the progress of the project could be monitored, and activities such as training courses and workshops, demonstration fields, and technical guidance in the innovation platforms (IPs), seed

production, etc., were continued. The construction of the molecular breeding facility in Wad Medani had to be suspended. Instead, we agreed at the 6th JCC meeting in Cairo that the production of certified wheat seeds would be implemented as a more urgent and effective measure for food production in the insecure period. By strengthening the public-private partnership (PPP), it was possible to produce large quantities of seeds, making significant contributions to the availability of high-quality certified seed and increasing wheat productivity.

### **1-5. Impact**

The results of the activities have led to effective achievements, and the project purpose has been fully achieved or exceeded the plan.

The overall goal was to develop wheat genetic resources that are adaptable to the hot and arid environment of Sudan, and molecular breeding techniques using selection markers are used to develop practical varieties. To implement this, Tottori University accepted seven long-term trainees, and a system was established in which ARC and SMA could work together to implement the project. The IPs were established to communicate the importance of the varieties to farmers and other stakeholders in the wheat value chain. Farmers at the IP sites demonstrated a 30-44% increase in wheat yield simply by using certified seeds of the new varieties, which motivated wheat producers to adopt the new technology. As a result, 1/3 of the wheat seed in Sudan is now related to the project. Furthermore, based on the results of this project, a collaborative project between JICA and WFP was initiated in the wheat value chain enhancement project in Sudan, which is expected to greatly contribute to food production in Sudan.

### **1-6. Sustainability**

The results of the activities have led to effective achievements, and the project purpose has been fully achieved or exceeded the plan.

The project trained seven PhD students at the United Graduate School of Agricultural Sciences at Tottori University to apply their knowledge to enhance wheat research for development in Sudan.

The SATREPS Wheat Project has adopted the innovation platform approach, where all stakeholders along the wheat value chain, including farmers and policymakers, are brought together to jointly identify and prioritize challenges and develop and implement solutions and work plans. As such, this is expected to raise awareness among farmers and other stakeholders, increase adoption of improved technologies, including improved varieties, and ultimately lead to sustainable wheat production. The innovation

platform approach ensures sustainability of technology dissemination and scaling up to new areas with support from technology transfer bodies at the Ministry of Agriculture and the ARC. In addition, strong public-private partnerships (PPPs) have been established, especially in seed production, which have contributed significantly to the availability of seeds of the adapted and newly released wheat varieties. Informal community-based seed production has also been promoted, where farmers in specific areas produce and distribute their seed within the community.

When maintained and regularly updated, multimedia content will serve as an effective means of raising farmers' awareness beyond the IP sites. As mentioned earlier, ARC maintains strong relationships and networks with regional and international research and development organizations and could share its experience in variety development, technology dissemination, and PPP activities with other countries with similar agro-ecologies, particularly in Sub-Saharan Africa.

The strategies and approaches used by the SATREPS Wheat Project, particularly IPs and PPPs, have raised awareness, contributed to the availability of high-quality seeds, increased technology adoption, and promoted sustainable wheat production. The support of the Ministry of Agriculture, ARC, and other relevant stakeholders and entities will ensure the sustainable dissemination and expansion of improved technologies to new areas. Recognizing the milestone achievement in wheat seed production, the Ministry of Agriculture and Forestry formed a Higher Committee for Wheat Seed Production and Marketing, which includes some members and partners of the project. The plan is to provide all the required high-quality seeds that could lead to maximizing productivity and production. Besides, ARC continues to support the Wheat Research Program for producing the basic seed required for continuous supply of the seed production chain. Given the projected impacts of climate change, particularly heat stress, on agriculture, research on climate-resilient wheat varieties and climate-smart technologies is essential. Investments in localized climate modeling and research on climate change impacts on crop performance are also critical for accurate planning and resilient agricultural systems. Moreover, enabling policies are crucial to ensure food security by providing access to improved technologies, credit, and extension services.

Considering its achievements and given the importance of post-harvest processes and value addition in maximizing farmers' returns from their own produce and promoting agricultural resilience and sustainability, the project team recommends empowering local rural communities and stimulating their local economic development, integrating gender and youth into such entrepreneurship for better livelihoods of local communities. Establishing entrepreneurial, community-based post-harvest processing facilities is

anticipated to reduce farmers' dependence on volatile commodity markets and encourage them to diversify their income sources by adding value to their products through processing, packaging, baking, and possibly branding.

## **2. Key Factors Affecting Implementation and Outcomes**

During the People's Revolution in 2018/19, the security situation delayed the project's kick-off and prevented Japanese experts from visiting Sudan. Then, the COVID-19 pandemic in 2020 and the political turmoil in October 2021 resulted in the suspension of some project activities, including experts' visits to Sudan, which affected the progress of some project activities. Later, the armed conflict between the paramilitary Rapid Support Force (RSF) and the Sudan Army Force (SAF), which started in Khartoum in April 2023 and spread to Gezira in December 2023, substantially affected most of the activities, especially the rehabilitation of the molecular and speed breeding facilities and laboratory equipment procurement process. Despite these challenges and difficulties, the project achieved almost all research-based and capacity-building activities. The final symposium of the Sudan SATREPS Wheat Project, “Innovative Technologies for Sustainable Wheat Production”: Building Resilience through Partnerships, held at Tottori University, Japan on February 13, 2025, aimed to bring together project members to present the project achievements and milestones and draw lessons and recommendations for future collaboration.

## **3. Evaluation of the results of the Project Risk Management**

Due to the risk of insecurity in the country during various obstacles faced by the project, both JICA and the Sudanese sites took preventive measures against any risk. The JICA staff were evacuated during the insecure periods in 2021 and 2023, and their movement was restricted on some occasions. However, both sites, together with Tottori University, continued to monitor the situation and the progress of the implementation of the project activities through weekly online meetings. The Sudanese site continued the implementation of the activities all the time in order not to miss any cropping season. Even after the conflict spread to Gezira in December 2023, the staff was evacuated to safe zones and continued implementing the activities in these safe sites in New Halfa, River Nile, and Northern states.

## **4. Lessons Learnt**

The SATREPS Wheat Project has made significant strides: breeding climate-resilient wheat, understanding the crop's response to stress, analyzing climate trends, and setting future directions for wheat production. Despite setbacks caused by

political turmoil, the project has successfully identified heat- and drought-tolerant wheat germplasm, made quality seed more available, and developed innovative research approaches to sustain wheat production. The full commitment of the project team, their team spirit, their determination to continue the work despite the difficulties, the strategic partnerships established with different stakeholders, the nature of the ARC structure and the distribution of its research stations across all agro-ecological zones, the support and some level of flexibility from the donors, such as JICA, the synergy and cooperation with all other existing projects, etc., were all factors that led the project to achieve these milestones despite the huge financial and security challenges. The strategies and approaches used by the SATREPS wheat project, particularly IPs and PPPs, have raised awareness, increased technology adoption, and promoted sustainable wheat production.

The project laid the foundation for future agricultural resilience in Sudan. This integrated strategy combines crop improvement, plant physiology, climate modelling, capacity building, and partnership development. Achievements highlight the need to invest in research, seed systems, and policy reforms to ensure food security and development. Lessons learned could guide future collaborations and interventions to restore and sustain agriculture in Sudan.

## **5. Performance**

Despite the difficulties faced by the project throughout its implementation time, the team spirit created within the project team, JICA, and JST was instrumental in achieving the objectives and purposes of the project. All parties established cooperative relationships through well-established communication channels, better understanding the needs for support during difficult times, showing some degree of flexibility and making appropriate decisions in response to changes in the situation during project implementation, and applying ideas that were instrumental in enhancing the effective implementation.

## **IV. For the Achievement of Overall Goals after the Project**

### **Completion**

As indicated in the PDM of the project and despite the challenges mentioned above, the project achieved 100% of almost all of the indicators and in some cases exceeded the indicators. The challenge of insecurity resulted in the suspension of the rehabilitation process was beyond the control of the project and its member. Nevertheless,

the project team proposed an alternative plan which was adopted during the 6<sup>th</sup> JCC meeting in August 2024 and successfully implemented.

## **1. Prospects to achieve Overall Goal**

Given the projected impacts of climate change, particularly heat stress, on agriculture, research on climate-resilient wheat varieties and climate-smart technologies is essential. Investments in localized climate modeling and research on climate change impacts on crop performance are also critical for accurate planning and resilient agricultural systems. Moreover, enabling policies are crucial to ensure food security by providing access to improved technologies, credit, and extension services.

In light of its achievements and given the importance of post-harvest processes and value addition in maximizing farmers' returns from their own produce and promoting agricultural resilience and sustainability, the project team recommends empowering local rural communities and stimulating their local economic development, integrating gender and youth into such entrepreneurship for better livelihoods of local communities. Establishing entrepreneurial, community-based post-harvest processing facilities is anticipated to reduce farmers' dependence on volatile commodity markets and encourage them to diversify their income sources by adding value to their products through processing, packaging, baking, and possibly branding.

## **2. Plan of Operation and Implementation Structure of the Sudan side to achieve Overall Goal**

The Agricultural Research Corporation of Sudan is the technical arm of the Ministry of Agriculture. As such, ARC is mandated to develop and implement research to develop the technologies and crop production systems needed to ensure high and sustainable crop productivity and food security. Technically, in addition to the researchers trained in this project, ARC has qualified researchers distributed in all agro-ecological zones, including all research stations in the wheat production zones. Under normal circumstances, ARC has a plan for the new intake of young scientists every 3-5 years, which keeps the technical capacity and capability sustainable. Financially, ARC is directly linked to the Ministry of Finance and Economic Planning, from where it secures the necessary funds for research, personnel, and social implementation by preparing and presenting short-, medium-, and long-term research plans and strategies. In

addition, ARC has a strong history of collaboration with major Consultative Group on International Agricultural Research (CGIAR centers such as ICARDA, CIMMYT (International Maize and Wheat Improving Center, IITA (International Institute of Tropical Agriculture, etc. and regional and international organizations through the implementation of joint research and social implementation activities. The extensive network of linkages with many bilateral and multilateral development agencies and regional and international research institutions enables ARC to achieve its development goals and sustain its activities. The ARC maintains its manpower through regular intake of young scientists and supporting staff to sustain the human resources necessary to conduct research for development and social implementation activities.

### **3. Recommendations for the Sudan side**

Sudan ARC had a good knowledge and long experience of wheat production in the country. Building on its experience in managing many international collaborative research projects, ARC managed the project and its budget closely and implemented the project as contracted in all respects. From the outset, however, the project suffered from obstacles such as civil unrest, the spread of infectious diseases, and political turmoil. In the second half of the project, the war that began in April 2023 forced many organizations and people, including the JICA office, to flee the country amid a very serious security situation. However, the project maintained a weekly online meeting with the local staff involved in this SATREPS, who kept the project going until the end. We would like to express our gratitude and respect to the Sudanese staff for their enthusiasm and commitment to seeing the project through to the end.

The agricultural sector in Sudan is facing an ongoing crisis due to the conflict between the Rapid Support Forces (RSF and the Sudan Armed Forces (SAF, exacerbated by climate change, biodiversity loss, and resource scarcity. The conflict has destroyed research infrastructure, displaced scientists, and disrupted breeding programs, severely impacting crop improvement efforts. The country risks long-term food insecurity and economic instability as key facilities are rendered non-functional. With food security at risk, fast-tracking breeding initiatives to restore productivity and resilience in the country's agricultural sector are urgently needed.

Agricultural research institutions, notably the Agricultural Research Corporation, have been severely impacted, with many facilities damaged and rendered inoperable. The crop breeding efforts and seed supply chain of key crops such as sorghum, millet, wheat, sesame, faba bean, chickpea, cotton, groundnut, sunflower, and sugarcane, which form the food system and economic backbone of the country, have suffered from the

destruction of infrastructure and facilities, and the displacement of researchers and skilled personnel.

Given these challenges, urgent action is needed to accelerate breeding programs inside and outside the country through partnerships with international research and academic institutions, international donors, and private seed companies. The use of advanced breeding techniques such as speed breeding, marker-assisted selection (MAS), and genome editing in foreign research facilities will enable the rapid development of climate-resilient, high-yielding, nutritious, and disease-resistant varieties of staple and cash crops in Sudan.

## **ANNEXES:**

ANNEX 1-1.1: List of Dispatched Expert

ANNEX 1-1.2: List of Machinery and Vehicle

ANNEX 1-1.3: List of Equipment

ANNEX 1-1.4: Training workshops and courses conducted in Sudan for different stakeholders along the wheat value chain

ANNEX 1-2.1: List of Project members

ANNEX 1-2.2: List of personnels involved in Project implementation in Sudan

ANNEX 1-2.3: List of long-term and short-term trainees

ANNEX 1-3.1: Material used in local training: Technological options for sustainable wheat production in Sudan (1<sup>st</sup> edition 2020)

ANNEX 1-3.2: Material used in local training: Technological options for sustainable wheat production in Sudan (2<sup>nd</sup> edition 2023)

ANNEX 2-2.1: List of publication and movie

ANNEX 2-2.2: List of oral and poster presentations

ANNEX 2-2.3: Award and broadcast

ANNEX 2-2.4: Final symposium abstract

ANNEX 2-2.5: Workshop and outreach

ANNEX 3-1. List of JCC Meeting held

ANNEX 3-2.1 PDM ver.1

ANNEX 3-2.2 PO ver. 1

ANNEX 3-3.1 PDM ver.2

ANNEX 3-3.2 PO ver.2

ANNEX 3-4.1 PDM ver.3

ANNEX 3-4.2 PO ver.3

ANNEX 3-5.1 PDM ver.4

ANNEX 3-5.2 PO ver.4

ANNEX 3-6.1 PDM ver.5

ANNEX 3-6.2 PO ver.5

ANNEX 4.1: R/D signed 2019

ANNEX 4.2: R/D signed 2020

ANNEX 4.3: R/D signed 2021

ANNEX 4.4: R/D signed 2023

ANNEX 4.5: 4<sup>th</sup> JCC Meeting R/D signed 2023

ANNEX 4.6: 5<sup>th</sup> JCC Meeting R/D signed 2023

ANNEX 4.7: R/D signed 2024

Annex 1-1.1. List of dispatched experts

Name of expert	Period		Breakdown by Year				Affiliate in Japan	Title
	Dispatch Start Date (Departure Date)	Dispatch End Date (Date of Return)	Year	Start Date	End Date	Dispatch Days		
Gorafi Yasir	2019/11/21	2019/12/5	FY 2019	2019/11/21	2019/12/5	15	Tottori University	Extraordinary associate professor
	2020/2/19	2020/3/3		2020/2/19	2020/3/3	14	Tottori University	
	2022/3/21	2022/4/1	FY 2021	2022/3/21	2022/3/31	11	Tottori University	
	2022/11/18	2022/11/28	FY 2022	2022/4/1	2022/4/1	1	Tottori University	
				2022/11/18	2022/11/28	11	Tottori University	
	2023/2/24	2023/3/7	FY2024	2023/2/24	2023/3/7	12	Tottori University	
	2024/8/3	2024/8/10		2024/8/3	2024/8/10	8	Kyoto University	
	2024/9/20	2024/9/29		2024/9/20	2024/9/29	10	Kyoto University	
2024/11/29	2024/12/7	2024/11/29		2024/12/7	9	Kyoto University		
2025/2/21	2025/3/1		2025/2/21	2025/3/1	9	Kyoto University		
Ryosuke Mega	2019/11/23	2019/11/30	FY 2019	2019/11/23	2019/11/30	8	Tottori University	Special Assistant Professor
Mitsuru Tsubo	2019/11/24	2019/11/30	FY 2019	2019/11/24	2019/11/30	7	Tottori University	Professor
	2020/2/19	2020/3/4		2020/2/19	2020/3/4	15	Tottori University	
Haruyuki Fujimaki	2019/11/27	2019/12/3	FY 2019	2019/11/27	2019/12/3	7	Tottori University	Professor
Hisashi Tsujimoto	2020/2/19	2020/3/4	FY 2019	2020/2/19	2020/3/4	15	Tottori University	Professor
	2023/2/24	2023/3/7	FY 2022	2023/2/24	2023/3/7	12	Tottori University	
	2024/8/4	2024/8/10	FY2024	2024/8/4	2024/8/10	7	Tottori University	
	2024/9/19	2024/9/29		2024/9/19	2024/9/29	11	Tottori University	
	2025/2/21	2025/3/1		2025/2/21	2025/3/1	9	Tottori University	
Takayoshi Ishii	2020/2/19	2020/3/2	FY 2019	2020/2/19	2020/3/2	13	Tottori University	Lecturer
Shun Sakuma	2020/2/26	2020/3/2	FY 2019	2020/2/26	2020/3/2	6	Tottori University	Assistant Professor
	2023/2/27	2023/3/7	FY 2022	2023/2/27	2023/3/7	9	Tottori University	Associate Professor
	2024/8/4	2024/8/10	FY2024	2024/8/4	2024/8/10	7	Tottori University	
	2024/9/21	2024/9/29		2024/9/21	2024/9/29	9	Tottori University	
Kinya Akashi	2024/8/3	2024/8/10	FY2024	2024/8/3	2024/8/10	7	Tottori University	Professor

**Annex 1-1.2. List of Machinery and Vehicles**

<b>No.</b>	<b>Item</b>	<b>Amount</b>	<b>Price</b>	<b>handover</b>
1	TOYOTA LAND CRUISER 2019 (Plate No. 114/23)	1	NA	22nd January 2026
2	TOYOTA HILUX 2019 (Plate No. 114/24)	1	NA	22nd January 2026
3	Automated metreological station (A set of infrared thermometers, camera, air temperature and humidity sensor, and soil moisture sensor)	1	¥4,464,900	2nd November 2020
4	Wintersteiger Plot seed XL	1	€ 30,340	1st March 2022
5	Wintersteiger Classic Plus Plot Combine	1	€ 107,645.00	6th July 2022
6	JOHN DEERE AGRICULTURAL TRACTOR 4WD 95 HP	1	US\$42,000.00	21th October 2025
7	ABOLLO , LASER LEVELER	1	US\$34,000.00	21th October 2025

### Annex 1-1.3. List of Equipment

No.	Item	Amount	Price	handover
1	A set of sensitive balance	1	¥159,720	2nd November 2020
2	U-600PF Porometer/Fluorometer	1	¥3,839,999	14th March 2021
3	HydroSense II Handheld Soil Moisture Sensor	2	¥404,000	
4	Wintersteiger Plot seed XL	1	€ 30,340	1st March 2022
5	HP EliteBook 840	1	SDG 910,000	
6	LI-3000C Portably Leaf Area Meter	1	¥2,442,880	1st April 2022
7	HydroSense II Handheld Soil Moisture Sensor	2	¥404,000	
8	Speakerphone MM-MC28 and Webcamera CMS- V50BK	1	¥76,560	6th July 2022
9	Wintersteiger Classic Plus Plot Combine	1	€ 107,645.00	
10	Container House working facility (12 working offices with AC, sanitary facilities and working place and table)	1	¥3,322,905	15th November 2022
11	PCRAC196	2	€ 9,442.00	23rd February 2023
12	Microprocessor LAC-5040S0	1	€ 3,983.47	
13	Drying oven LDO-100E	1	€ 998.00	
14	Digital water bath LWB-122DL	1	€ 590.00	
15	Ultrapure water system DR-TOC-UF	1	€ 2,240.00	
16	UV lamp radiator EUV-254-HLP	1	€ 102.00	
17	Ultrafiltration capsule UF EU-HLP-02	1	€ 405.60	
18	Hydrolab Basic water deionizer DB-015-oK	1	€ 940.00	
19	Hydrolab Demi water tap A-KR-TOF-011	1	€ 124.80	
20	Silicone tubing ST 1500-8	4	€ 5.12	
21	Manitowoc Flake ice maker 4.667.960	1	€ 3,255.00	
22	Laminar Flow cabinet CR870FL	1	€ 4,997.00	
23	HEPA Filter FL001	1	€ 798.00	
24	Digital pH meter 351 001	1	€ 602.00	
25	pH Glass electrode 924 005	2	€ 150.00	
26	Nichipet EX2 2uL 00-NPX2-2	4	90,200 JPY	28th April 2025
27	Nichipet EX2 10uL 00-NPX2-10	4	90,200 JPY	
28	Nichipet EX2 20uL 00-NPX2-20	4	81,620 JPY	
29	Nichipet EX2 100uL 00-NPX2-100	4	81,620 JPY	
30	Nichipet EX2 200uL 00-NPX2-200	4	81,620 JPY	
31	Nichipet EX2 1000uL 00-NPX2-1000	4	81,620 JPY	
32	Nichipet EX2 5000uL 00-NPX2-5000	1	22,550 JPY	
33	Single-stage spring 2uL 00-NX2-0200002	4	968 JPY	
34	Single-stage spring 10uL 00-NX2-0200010	4	968 JPY	
35	Single-stage spring 20uL 00-NX2-0200020	4	968 JPY	
36	Single-stage spring 100uL 00-NX2-0200100	4	968 JPY	
37	Single-stage spring 200uL 00-NX2-0200200	4	968 JPY	
38	Single-stage spring 1000uL 00-NX2-0201000	4	968 JPY	
39	Seal Spring 00-NX2-2205000	1	770 JPY	
40	Nozzle Cylinder Set For 2uL 00-NX2-0400002	8	12,408 JPY	
41	Nozzle Cylinder Set For 10uL 00-NX2-0400010	8	12,408 JPY	
42	O-Ring, Seal Ring Set 20uL 00-NX2-0500020	8	6,160 JPY	
43	O-Ring, Seal Ring Set 100uL 00-NX2-0500100	8	6,160 JPY	
44	O-Ring, Seal Ring Set 200uL 00-NX2-0500200	8	6,160 JPY	
45	O-Ring, Seal Ring Set 1000uL 00-NX2-0501000	8	6,160 JPY	
46	O-Ring, Seal Ring Set 5000uL 00-NX2-05050000	2	1,540 JPY	
47	Nozzle filter 00-NX2-0601000	2	3,872 JPY	
48	Nozzle filter 00-NX2-0615000-20	1	682 JPY	
49	Pipette Stand 00-MLT-STD2	7	39,270 JPY	
50	Nichipet EX2 Multi 8 Channel 00-NPM-8SP	1	55,055 JPY	
51	Nichipet EX PLUS2 20uL 00-NPLO-20	1	25,850 JPY	
52	Nichipet EX PLUS2 100uL 00-NPLO-100	1	25,850 JPY	
53	Nichipet EX PLUS2 200uL 00-NPLO-200	1	25,850 JPY	
54	Nichipet EX PLUS2 1000uL 00-NPLO-1000	1	25,850 JPY	
55	Nichipet EX PLUS2 5000uL 00-NPLO-5000	1	31,020 JPY	

56	Seal spring 20uL 00-LO2-0200020	1	1,936 JPY	
57	Seal spring 100uL 00-LO2-0200100	1	1,936 JPY	
58	Seal spring 200uL 00-LO2-0200200	1	1,936 JPY	
59	Seal spring 1000uL 00-LO2-0201000	1	1,936 JPY	
60	Seal spring 5000uL 00-LO2-2205000	1	1,936 JPY	
61	O-Ring, Seal Ring Set 20uL 00-LO2-0300020	2	5,434 JPY	
62	O-Ring, Seal Ring Set 100uL 00-LO2-0300100	2	5,434 JPY	
63	O-Ring, Seal Ring Set 200uL 00-LO2-0300200	2	5,434 JPY	
64	O-Ring, Seal Ring Set 1000uL 00-LO2-0301000	2	5,434 JPY	
65	O-Ring, Seal Ring Set 5000uL 00-LO2-0305000	2	12,584 JPY	
66	Nozzle Filter For 1000uL 10pcs 00-LO2-0601000	1	1,936 JPY	
67	Pipette Stand 00-MLT-STD2	1	5,610 JPY	
68	Automatic Weather Station	2	17,140.00 Euro	21th October 2025
69	Electric Grain Grinder Mill	4	1,508.00 Euro	
70	Automatic Water Still	2	4,574.22 Euro	
71	Incubator	2	8,499.20 Euro	
72	Laboratory Freezer	2	3,059.38 Euro	
73	Autoclave	1	4,606.00 Euro	
74	Compound Microscope	1	2,265.90 Euro	
75	Cabinet	1	49.00 Euro	
76	Experimental Laboratory Table	1	1,955.00 Euro	
77	Automatic Counter Machine Microcomputer	5	1,045.00 Euro	
78	Portable Leaf Area Meter	5	6,970.00 Euro	
79	Soil Nutrient Tester	4	7,934.80 Euro	
80	Electronic Digital Precision Balance	4	1,336.96 Euro	
81	Psychomotor	5	2,195.00 Euro	
82	Chlorophyll Meter	5	2,620.00 Euro	
83	Multi-rice Wheat Thresher Roller	4	4,316.00 Euro	
84	Hanging Balance	9	1,499.85 Euro	
85	Balance	4	6,374.40 Euro	
86	Balance Scale	5	766.00 Euro	
87	Handheld Crop Sensor	5	6,895.00 Euro	
88	AA Current Meter	2	9,318.00 Euro	
89	Portable Parshall Flume	2	9,778.00 Euro	
90	HPE ProLiant DL380 Gen10	3	18,207.00 Euro	
91	FSP CHAMP 6KL	2	1,998.00 Euro	
92	Floor Stand Cabinet Server Rack	1	765.00 Euro	

#### Annex1-1.4. Training workshops and courses conducted in Sudan for different stakeholders along the wheat value chain

No	Type	Title	Date and place	Participant
1	Training workshop	Innovation platforms for sustainable wheat production (In partnership with AMTAAR CO.)	9-11 March 2021, Ad-Dabbah, Northern State	26 participants (extensionists, seed production technicians, and specialists)
2	Training workshop	Seeds: The Cornerstone of Profitable and Sustainable Crop Production (In partnership with AMTAAR CO.)	13-15 March 2022, Al Goled, Northern State, Sudan.	25 participants (extensionists, seed production technicians, and specialists)
3	Training course	Technological Options for Profitable and Sustainable Wheat Production (In partnership with AMTAAR CO.)	16-17 March 2022, Ad-Dabbah, Northern State	22 farmers from Al-Tadamon IP
4	Training workshop	Skills Development in Baking and Confectionery	22 April 2024, Aliab IP, Sudan	20 housewives
5	Training course	Mechanization in Wheat Production Operations in Sudan (In partnership with AMTAAR CO.)	23-26 October 2023, Mosaad Training Centre, Gezira Scheme	25 field machinery operators
6	Training course	Classical and Modern Breeding Methodologies for Improving Crop Production Considering Climate Change	10-14 December 2023, ARC, Wad Medani, Gezira, Sudan	25 young researchers
7	Training workshop	Local compost preparation and integrated weed management in the field	January 7, 12, 2023, Tayba and Wad Hussain IPs	57 farmers from Tayba and Wad Hussain IPs
8	Training workshop	Local compost preparation and integrated weed management in the field (In partnership with AMTAAR CO.)	January 18, 2023, Al-Tadamon IP, Northern State	25 farmers from Tayba and Wad Hussain IPs
9	Training workshop	Baking and Confectionery Skills Development	23-25 April 2024, Hudeiba, River Nile, Sudan	50 housewives and young female

10	Training course	Wheat Production Technologies in Sudan (In partnership with TAATII, Harvest Investment Co., and the Agricultural Bank of Sudan (ABS))	24-25 December 2024, New Halfa Research Station, New Halfa	33 Farmers, technicians, and agricultural engineers from public and private companies
11	Training course	Wheat Production Technologies in Sudan (In partnership with TAATII, Harvest Investment Co, and the ABS)	29-30 December 2024, New Halfa Research Station, New Halfa	41 farmers, technicians, and agricultural engineers from public and private companies
12	Training workshop	Technical packages for Wheat crop and seed production (In partnership with TAATII)	31 December 2024, Dongola	54 farmers from Northern State
13	Training course	Wheat production technologies and integrated technical management for crop seeds (In partnership with TAATII)	5-6 January 2025, Dongola Research Station, Dongola	21 participants (extension workers, seed production technicians, and officers)
14	Training workshop	Seed production aspects in collaboration (In partnership with TAATII and Harvest Investment Co.)	11 January 2025, Village 13, Argine IP, New Halfa	35 farmers in the IP site
15	Training workshop	Seed production aspects in collaboration (In partnership with TAATII and Harvest Investment Co.)	31 January 2025, New Halfa Research Station, New Halfa	39 farmers, extension workers, technicians, and agricultural engineers.

### Annex 1-2.1. List of Project members

#### (Management Level)

Organization	Position	Name	Email Address	Reference
ARC	Project Director	Dr. Abubakr I. M. Hussein/Prof. Abdelmoneim Taha		
ARC	Project Dupty Director	Prof. Dafalla Dawoud		
SMA	Project Dupty Director	Dr. Hanan Rabah		

#### (Counterparts)

Organization	Position	Name	Email Address	Reference
ARC	Project Manager & Group 1 Leader	Prof. Izzat Tahir		
ARC	Group 2 Leader	Dr. Hala Elamin		
ARC	Group 3 Leader	Dr. Abu Sefyan Saad		
SMA	Group 4 Leader	Prof. Imad-Eldin A. Ali-Babiker/Dr. Abuelgasim Musa		
ARC	Group 5 Leader	Ms. Amani Idris		

#### (Japanese side)

Organization	Position	Name	Email Address	Reference
Tottori U	Chief Advisor & Group 1 Leader	Prof. Hisashi Tsujimoto		
Utsunomiya U	(Group 1)	Dr. Okamoto		
Tottori U	(Group 1)	Dr. Shun Sakuma		
Tottori U	Sub Leader & Group 2 Leader	Dr. Hiroyuki Tanaka		
Tottori U	Group 3 Leader	Prof. Kinya Akashi		
Tottori U	Group 4 Leader	Prof. Mitsuru Tsubo		
Kyoto U	Group 5 Leader	Dr Yasir Sereg Alnor Gorafi		
Tottori U	Administration	Ms. Yumi Sakai		
Tottori U	Administration	Ms. Mari Sakuma		
Tottori U	Researcher	Dr. Nasrein M. Kamal		
Tottori U	Researcher	Dr. Mohamed Yousif Balla		

#### (Project Staff)

Organization	Position	Name	Email Address	Reference
JICA Wheat Project	Driver	Mr. Bilal Hussien		
JICA Wheat Project	Secretary	Ms. Julia		

#### (JICA Project Coordinator)

Organization	Position	Name	Email Address	Reference
JICA	Project Coordinator	Mr. Takafumi Konaka		
JICA	Project Coordinator	Ms. Sachiko Shah		

**Annex 1-2.2. List of personnels involved in Project implementation in Sudan**

No	Name	Organization	Position (Status)	Group	Participation period			
					Start		End	
					Year	Month	Year	Month
1	Izzat Sidahmed Ali Tahir	ARC	Breeder, Project Manager	Group 1	F3+F5	6	R7	3
2	Nasrein Mohamed Kamal	ARC	Biotechnology	Group 1	H30	6	R4	3
3	Ashraf M. A. Elhashimi	ARC	Breeder	Group 1	H30	6	R7	3
4	Salah Mohamed Eltayeb	ARC	Pathology	Group 1	H30	6	R7	3
5	Modathir G. A. Abdallah	ARC	Breeder	Group 1	H30	6	R7	3
6	Jassir Faroug	ARC	Breeder	Group 1	H30	6	R7	3
7	Awad Ahmed Elawad	ARC	Breeder	Group 1	H30	6	R7	3
8	Mohammed Yousif Balla Abdalla	ARC	Breeder	Group 1	R1	10	R4	9
9	Monir Idres Yahaya Ahmed	ARC	Breeder	Group 1	R3	4	R7	3
10	Amir Ismail Ibrahim Emam				R4	10	R7	9
11	Sarra Mehesi	ARC	Breeder	Group 1		4	R7	3
12	Elfadil Mohamed Eltayeb	ARC	Breeder	Group 1				
13	Mazin Mahjob	ARC	Breeder	Group 1				
14	Hala M. Mustafa	ARC	Breeder	Group 2	H30	6	R7	3
15	Ikram Elsadig Suliman Mohamed	ARC	Breeder	Group 2	R4	10	R7	3
16	Abusufyan Ibrahim Saad	ARC	Biotechnology	Group 3	H30	6	R7	3
17	Salma Osman Mohamedkhair Osman	ARC	Molecular biology	Group 3	R4	10	R7	3
18	Hanan Rabbah	Sudan Meteorological Authority	Project Vice Manager	Group 4	H30	6	R7	3
19	Imad-Eldin A. Ali-Babiker	ARC	Crop modeling	Group 4				
20	Abuelgasim Ibrahim Idris Musa	Sudan Meteorological Authority	Early Warning Unit	Group 4	R4	10	R7	3
21	Almutaz Abdelkarim Abdelfattah Mohammed	ARC	Crop modeling	Group 4	R3	4	R7	3
22	Amani M. Idris	ARC	Crop physiology and modeling	Group 5	H30	6	R7	3
23	Elrasheed Abdalla Fageer	ARC	Socioeconomics	Group 5	H30	6	R7	3
24	Elmoiz Fadul	ARC	Crop Nutrition	Group 5	H30	6	R7	3
25	Alawia Osman	ARC	Socioeconomics	Group 5				
26	Abdelhameed Mgbool	ARC	Socioeconomics	Group 5	H30	6	R7	3
27	Omer Elshiekh	ARC	Crop breeding and agronomy	Group 5				
28	Mohamed Yousif Dafalla	ARC	Crop mechanization and irrigation	Group 5				
29	Islam Mohamed Kheer	Ministry of Agriculture and Forestry	National Wheat Production Project	Group 5	R3	4	R7	3
30	Mubarak Elsheikh	Ministry of Agriculture and Forestry	Seed Administration	Group 5				
31	Omaima Abdelgadir Elomrani	Ministry of Agriculture and Forestry	Seed Administration	Group 5	R3	4	R7	3
32	Abdelmajeed Mohamed Eltayeb	Ministry of Agriculture and Forestry	Planning and Agricultural Economics	Group 5	H30	6	R7	3

Annex 1-2.3. List of long-term and short-term trainees

No	Name	Organization	Position (Status)	Training	Group	University	PhD thesis title
1	Mohammed Yousif Balla Abdalla	ARC	Breeder	PhD	Group 1	Tottori University	Harnessing genetic diversity of the wild emmer wheat ( <i>Triticum turgidum</i> ssp. <i>dicoccoides</i> ) for wheat breeding
2	Monir Idres Yahya Ahmed	ARC	Breeder	PhD	Group 1	Tottori University	Identification of QTLs for seed dormancy and heat stress tolerance in wheat backcrossed recombinant inbred line populations developed using <i>Aegilops tauschii</i> intraspecific variation
3	Amir Ismail Ibrahim Emam	ARC	Breeder	PhD	Group 1	Tottori University	Sustainable wheat production under climate change: Interventions to increase the nutrients use efficiency of bread wheat
4	Ikram Elsadig Suliman Mohamed	ARC	Breeder	PhD	Group 2	Tottori University	Exploiting genetic diversity in <i>Aegilops tauschii</i> to improve wheat flour quality under heat stress conditions
5	Salma Osman Mohamedkhair Osman	ARC	Molecular biology	PhD	Group 3	Tottori University	Exploring metabolome changes in wheat ( <i>Triticum aestivum</i> ) under heat stress using Fourier transform infrared spectroscopy
6	Abel Gasim Ibrahim Idris Musa	Sudan Meteorological Authority	Early Warning Unit	PhD	Group 4	Tottori University	Relationship of wheat yield with temperature in large irrigation areas of Sudan
7	Almutaz Abdelkarim Abdelfattah Mohammed	ARC	Crop modeling	PhD	Group 4	Tottori University	Canopy temperature and energy balance of irrigated wheat in the hot-arid environment of Sudan

1	Ashraf M. A. Elhashimi	ARC	Breeder	Short training	Group 1	Tottori University	
2	Modathir G. A. Abdallah	ARC	Breeder	Short training	Group 1	Tottori University	
3	Hala M. Mustafa	ARC	Breeder	Short training	Group 2	Tottori University	
4	Abusufyan Ibrahim Saad	ARC	Biotechnology	Short training	Group 3	Tottori University	
5	Amani M. Idris	ARC	Crop physiology and modeling	Short training	Group 5	Tottori University	



هيئة البحوث الزراعية

برنامج بحوث القمح بالتعاون مع جامعة توتوري في اليابان

مشروع

تقانات مبتكرة لإنتاج مستدام للقمح

(تمام)



الخيارات التقنية  
لإنتاج مستدام للقمح  
في السودان





هيئة البحوث الزراعية

برنامج بحوث القمح بالتعاون مع جامعة توتوري في اليابان

مشروع تقانات مبتكرة لإنتاج مستدام للقمح  
(تمام)

# الخيارات التقنية لإنتاج مستدام للقمح في السودان



## مشروع تقانات مبتكرة لإنتاج مستدام للقمح (تمام)

### مقدمة

يعد القمح من أهم محاصيل الأمن الغذائي في العالم و هو من أكبر مصادر البروتين النباتي للإنسان. يعتبر القمح من محاصيل المناطق الباردة ومعتدلة المناخ مما جعل زراعته تقليدياً تنحصر في المناطق الباردة نسبياً في شمال السودان (شمال خط عرض 17° شمالاً). القمح محصول قديم في السودان قدم الحضارة النوبية حيث يحمل اسماً نوبياً مثله مثل الذرة والشعير والنخيل وغيرها.

نسبة للزيادة المضطربة في إستهلاك القمح كان لا بد من التفكير في التوسع في زراعته جنوباً إلى السهول الطينية حتى خط عرض 13° شمالاً (الجزيرة، الرهد، حلفا الجديدة، النيل الأبيض، السوكي ومشاريع النيل الأزرق). أهم التحديات التي واجهت ذلك التوسع هو إستنباط الأصناف المناسبة التي تتحمل الإجهاد الحراري بالإضافة إلى إيجاد التقانات المناسبة التي تمكن المحصول من تجاوز غلواء الإجهاد الحراري في تلك المناطق.

لمواجهة هذه التحديات تمكنت هيئة البحوث الزراعية من إستنباط أصناف قمح ذات إنتاجيات عالية ولها القدرة على الملائمة والتأقلم مع درجات الحرارة المرتفعة بالإضافة إلى إستحداث التقانات المناسبة لزراعة القمح تحت ظروف الإجهاد الحراري مما أدى إلى التوسع في زراعته.



القمح من المحاصيل المتناقلة لبيئات مختلفة، ولذا يجب مراعاة متطلبات كل بيئة للحصول على إنتاجية عالية...

## بيئات إنتاج القمح في السودان

- بيئات إنتاج القمح في السودان تتفاوت تفاوتاً كبيراً ومؤثراً من حيث المناخات السائدة والتنوع في التربة وعوامل الإنتاج الأخرى مما قد يستوجب التعامل مع كل بيئة بخيارات تقنية مختلفة.
- التباين في المناخ يتمثل في درجات الحرارة والرطوبة النسبية السائدة خلال الموسم حيث ترتفع درجات الحرارة تدريجياً كلما إتجهنا من الشمال إلى الجنوب فنجد أن مناطق شمال السودان أكثر برودة من أواسط وشرق السودان.
- تمثل وجود رطوبة نسبية عالية في منطقة حلفا الجديدة مقارنة بباقي مناطق زراعة القمح بيئة مناسبة لبعض الأمراض خاصة أمراض الصدأ (صدأ الساق والأوراق) مما يستوجب إختيار الأصناف المقاومة لهذه الأمراض في تلك المنطقة.
- الاختلاف في التربة بين بيئات زراعة القمح في السودان يتمثل في التباين في خواصها الفيزيوكيميائية والمورفولوجية حيث تختلف أراضي الرسوبيات الحديثة (أراضي الجروف) عن أراضي الكرو والتروس العليا في شمال السودان.
- الإختلاف في الخواص الفيزيوكيميائية يتمثل في قوام التربة (نسبة الطين) وقلويتها ومدى تأثرها بالأملاح ومحتوياتها من العناصر المغذية مما يستوجب معالجات معينة في حال وجود معيقات مرتبطة بتلك الخواص.
- الإدارة الجيدة لمحصول القمح وبكل ما ذكر من تنوع في البيئات تستوجب إدارة رشيدة لعمليات تحضير التربة، الري والتسميد من حيث الطرق المطلوبة وتوقيتها وفترات الري وجرعات السماد الموصى بها.

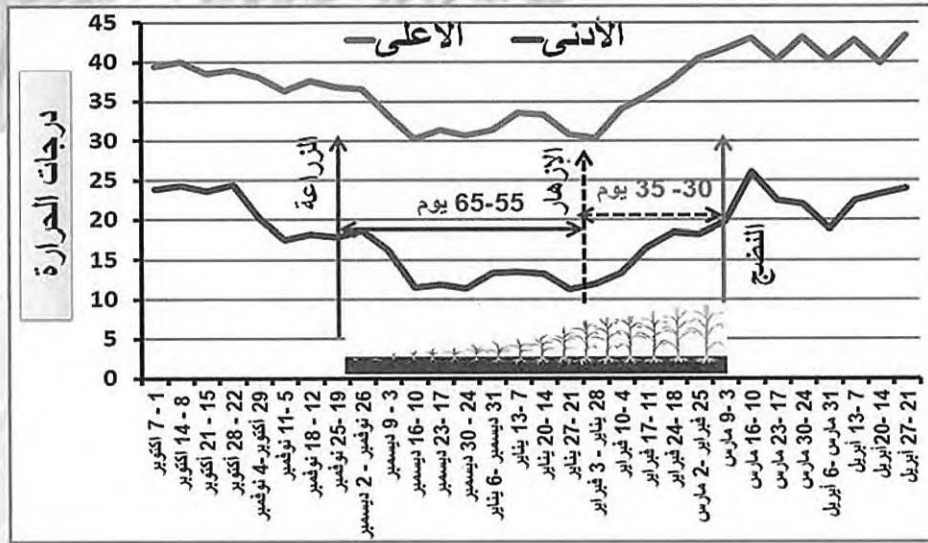


الإهتمام والالتزام بتطبيق تقانات انتاج القمح يجد من آثار الاجهاد الحراري ويؤدي إلى الحصول على انتاجيات عالية ومربحة ...

## الخيارات التقنية لإنتاج مستدام للقمح:

نسبة لقصر الموسم الزراعي للقمح في السودان وإرتفاع درجات الحرارة (الشكل 1)، يتحتم على المنتج الإهتمام والالتزام بتطبيق كافة التقانات الخاصة بإنتاج القمح وذلك للحد من آثار الإجهاد الحراري والحصول على إنتاجيات عالية وبالتالي عائد إقتصادي مجزي من محصول القمح.

الهدف الرئيسي لهذا الكتيب هو عرض الخيارات التقنية المناسبة لكل مناطق إنتاج القمح في السودان من أجل إنتاج مستدام ومجزي.



الشكل (1): درجات الحرارة الأسبوعية في ود مدني إبتداء من الأول من أكتوبر

لضمان انتاج مريح ومستدام يوصى باتباع نظام الادارة المتكاملة للمحصول  
والاستخدام الأمثل للمدخلات والمتابعة اللصيقة للمحصول في كل مراحل نموه...

## موجهات هامة

يتميز القمح عن أغلب المحاصيل الحقلية الأخرى في السودان بسهولة زراعته وإدارة حقله وذلك لأن معظم العمليات الفلاحية تتم باستخدام الآلات الزراعية مع الإعتماد على عدد قليل من الأيدي العاملة. ولكن هنالك موجهات هامة يجب إتباعها:

• لتحقيق إنتاج مريح ومستدام لمحصول القمح في ظل ظروف الإجهاد الحراري في السودان يوصى دائماً بإتباع نظام الإدارة المتكاملة للمحصول (Integrated Crop Management, ICM)، الإدارة المتكاملة للمحصول هي التي تراعي سلسلة القيمة الكاملة بما في ذلك إتباع الدورة الزراعية المناسبة، والتنوع المناسب للمحاصيل، والتطبيق المناسب وفي الوقت المناسب لمختلف الممارسات الزراعية (مثل إدارة التربة والمياه، وتغذية المحاصيل، وإدارة الآفات، إلخ...) والعوامل الاجتماعية والإقتصادية والبيئية والتي يمكنها أن تخفف من التأثير السلبي للإجهاد الحراري على غلة المحصول والنوعية للإستخدام النهائي.

• تتكامل كل الخيارات التقنية لزراعة القمح لبلوغ الإنتاجية المرجوة. لذلك فإن الإخلال في التطبيق الصحيح لأي منها قد يؤدي الى فقدانك قدراً كبيراً من الإنتاج وبالتالي الربحية.



لحفاظ على صحتك وعلى البيئة يجب الالتزام بإجراءات السلامة عند استخدام المبيدات...

- استخدام أي مدخل أو تقانة من تقانات إنتاج القمح يجب أن يكون مرتبطاً بالعائد أو الجدوى الاقتصادية من استخدامه. مثلاً إذا كانت الزيادة في الإنتاجية لا تغطي تكلفة السماد الزائد فلا داعي للزيادة في استخدامه إلا لأغراض أخرى مثل إنتاج التقاوي.
- التفريط أو الإفراط في استخدام المدخلات المختلفة مثل الأسمدة والمبيدات والري والحرث المتكرر غير الضروري لديه تأثير مباشر على الإنتاج الاقتصادي المربح وربما يضر بالإقتصاد القومي.
- عند استخدام وتطبيق المبيدات يجب مراعاة لبس الملابس الواقية والكمادات والقفازات للحماية من التعرض للسموم. عدم إتباع الإرشادات في استخدام المبيدات يسبب ضرراً مباشراً لصحتك وللبيئة.
- الإخلال في تطبيق كل الخيارات التقنية بالصورة الصحيحة يؤدي الي فقدان نسبة مقدرة من الإنتاج وبالتالي الربحية المرجوة. وهذا يظهر جلياً في التباين الكبير بين المزارعين في المنطقة الواحدة بل في النمرة الواحدة.
- في المقابل عند التطبيق الصحيح لكل الخيارات التقنية فإن عدد كبير من المزارعين في مناطق مختلفة من السودان قد حققوا إنتاجيات عالية فاقت 20 جوال للفدان (2 طن للفدان) بل إن بعض المزارعين حققوا أكثر من 28 جوال في الجزيرة وأكثر من 34 جوال في الشمالية.



اتباع الدورة الزراعية المناسبة يعتبر من أهم عناصر الحفاظ على الموارد الطبيعية...

لذا يجب الحرص على تطبيق التقانات تطبيقاً صحيحاً ومتابعة تطبيقها ميدانياً لأن ذلك من شأنه أن يساهم في رفع الإنتاجية والربحية وسط الغالبية العظمى من المزارعين في السودان وبالتالي المساهمة الفاعلة في الأمن الغذائي القومي. ويمكن تلخيص تقانات إنتاج القمح في السودان كالاتي:

### 1. الالتزام بالدورة الزراعية:

- إتباع الدورة الزراعية المناسبة من أهم عناصر الحفاظ على الموارد الطبيعية وخاصة الأرض وبالتالي الزراعة المستدامة.
- لا يوصى بزراعة محصول القمح عقب أي محصول نجيلي (ذرة، ذرة شامي، دخن، قمح، إلخ) وذلك لحماية التربة من الإنهك وللتقليل من مخاطر الآفات والأمراض وتأثير الحشائش النجيلية والخبثية مثل العدار الذي يصعب مكافحته يدوياً وتشكل المكافحة الكيميائية زيادة مقدرة في تكلفة الإنتاج.
- يستحسن زراعة محصول القمح عقب محاصيل غير نجيلية مثل القطن والبقوليات والخضروات وغيرها.



خلق المهد الجيد للمحصول من خلال إتباع إرشادات تحضير الأرض بشكل اللبنة الأولى للنجاح...

## 2. تحضير الأرض:

يعتبر الاهتمام بتوفير المهد الجيد للبذور والخالي من الحشائش من أهم مقومات نجاح إنتاج القمح، ولكي نتحصل على مهد مستو وذو نعومة جيدة والتي تساعد على زراعة القمح بالآلة بكفاءة عالية يوصى بإتباع الخطوات التالية:

- الحرث المبكر أثناء الخريف بالطراد أو الخلل أو بالدسك هرو في نهاية أغسطس / أوائل سبتمبر وذلك للإستفادة من رطوبة الأرض وكسر صلابتها وإزالة الحشائش قبل نضوج بذورها وكذلك لتهيئة التربة لإمتصاص أكبر قدر ممكن من الماء يساعد في إعدادها وريها مستقبلاً.
- في المناطق التي لا توجد بها أمطار مثل الشمالية ونهر النيل يوصى بعمل تروية خلال النصف الثاني من أكتوبر (إن أمكن) وذلك للمساعدة في إنبات الحشائش وتوفير رطوبة مقبولة في التربة تساعد على التحضير الجيد للأرض وإنسياب الريّة الأولى للقمح.



يوصى باستخدام التسطيح بالليزر في الأراضي التي تعاني من مشاكل التسوية...

- الحرث الثاني للأرض بالدسك هرو أو أي آلة شبيهة عندما تسمح رطوبة التربة بذلك في سبتمبر / أكتوبر بغرض تنعيم التربة وضمان توفير المهد الجيد.
- الحرث الثاني للأرض بالدسك هرو أو أي آلة شبيهة عندما تسمح رطوبة التربة بذلك في سبتمبر / أكتوبر بغرض تنعيم التربة وضمان توفير المهد الجيد.
- وبعد ذلك تتم تسوية الأرض باستخدام الآلة المناسبة (الكمره، مربع قلوبال، الرخافة، الخ...) وذلك لردم الأماكن المنخفضة وإزالة المرتفعة منها.
- إن إقتضت الضرورة يمكن عمل التسطيح بالليزر حيث أن عملية التسوية هي التي تساعد على الإدارة الجيدة لمياه الري وإنسيابها وتفادي الغرق خاصة أثناء الري الأولي.
- يجب تجنب استخدام الدسك 3 صاجة إلا في الأراضي الموبوءة بالحشائش المعمرة (مثل النجيله والسعدة) لأنه يتسبب في إحداث مجاري وأخاديد في الحقل مما يؤثر سلباً على عملية الري والإنبات.



إختيار الصنف المناسب لكل موقع والحصول على التقاوي من مصادرها الموثوقة هو الأساس لنجاح المحصول والحصول على الانتاجية الوفيرة...

### 3. الأصناف الموصى بها:

- هنالك العديد من الأصناف التي أجيّزت لزراعتها في مناطق إنتاج القمح في السودان. كل الأصناف المجازة لديها القدرة على تحمل الإجهاد الحراري ولكن بدرجات متفاوتة حسب مراحل نمو المحصول.
- يوصى بزراعة الأصناف التي أُنْتَبِطت في هيئة البحوث الزراعية وأجيّرت بواسطة اللجنة القومية للأصناف والتي يمكن تقسيمها إلى ثلاث مجموعات:
  - 1.3 أصناف متأخرة النضج نسبياً مثل إمام، تقانة، أرقين، ركية، عجيب وعكاشة ويفضل زراعتها خلال الأسبوع الثاني والثالث من نوفمبر ويجب تفادي زراعتها عندما تتأخر الزراعة عن المواعيد الموصى بها لأي سبب من الأسباب.
  - 2.3 أصناف متوسطة النضج مثل وادي النيل، دبيرة، النيلين، خليفة، خديوي وتزرع خلال الأسبوع الثالث والرابع من نوفمبر.
  - 3.3 أصناف مبكرة النضج نسبياً مثل بوهين، نبتة، قمريّة، أمل، جواهر، صلاح، الشبيك وأشري (تزرع في الأسبوع الأخير من نوفمبر وحتى الأسبوع الأول من ديسمبر في الولايات الشمالية).
  - 4.3 هنالك أصناف ليست لديها مقاومة لأمراض الصدأ مثل النيلين، وادي النيل، أمام وتقانة ولذلك لا يوصى بزراعتها في حلفا الجديدة إلا عند توفر المبيد الموصى به لمكافحة هذه الأمراض.
  - 5.3 تمت التوصية بزراعة عدد من أصناف القمح القاسي (الديورم) في السودان مثل شام-1، أرقو، زيداب، بساتنة وود البر ويفضل زراعتها خلال الأسبوع الثاني إلى الرابع من نوفمبر.



الأعداد الجيد للتقاوي يؤدي الى التخلص من البذور الضامرة والمكسورة وبذور الحشائش الضارة والشوائب الأخرى...

#### 4. إعداد التقاوي:

- دور التقاوي محوري في تحديد إنتاجية المحاصيل فهي المدخل الأساسي لزيادة الإنتاجية، وتعتمد فاعلية وتأثير المدخلات الأخرى مثل الري والأسمدة وغيرها على استخدام التقاوي المحسنة ذات الجودة العالية.
- يجب الحرص على الحصول على التقاوي المحسنة للأصناف المجازة من المصادر الموثوق بها.
- عمليات إعداد التقاوي تؤدي إلى التخلص من البذور الضامرة والمكسورة وبذور الحشائش الضارة والشوائب الأخرى بالإضافة إلى تعفير البذور.
- يوصى بتعفير التقاوي بمبيدات الحشرات والفطريات بالمعدلات الموصى بها وذلك حتى تتم وقاية المحصول من مخاطر الحشرات والأمراض الفطرية التي قد تصيبها عند الإنبات ومراحل النمو الأولى.



التوزيع الجيد والمتساوي للبذور في كل مساحة الحقل ضمان للتأسيس الجيد...

## 5. معدل التقاوي:

- يوصى باستخدام 50-60 كجم تقاوي للفدان تحت ظرف التحضير الجيد والتحكم في الريّة الأولى.
- في حالة القمح القاسي (الديورم) يوصى بإستخدام معدل تقاوي يتراوح بين 53 - 70 كيلوجرام للفدان في أراضي الكرو في نهر النيل.
- التحضير غير الجيد للأرض وعدم التحكم في الريّة الأولى وعدم الحرص على الزراعة بالألّة المناسبة وفي العمق المناسب من أهم الأسباب التي تؤدي الى تدني نسبة الإنبات وبالتالي التأسيس غير الجيد للمحصول الشيء الذي يضطر عدد من المزارعين لزيادة معدل التقاوي لتعويض هذا الخلل الذي يمكن تلافيه.
- في حالة التحضير الجيد تعطي هذه الكمية من التقاوي ما لا يقل عن 300-350 نبات في المتر المربع وهي الكثافة النباتية المطلوبة لتحقيق إنتاجيات عالية.
- أوضحت الدراسات أن القمح لديه القدرة على التعويض عند إستخدام معدلات تقاوي منخفضة من خلال طرح عدد من الخلف (الإشطاء) شريطة الإدارة الجيدة للمحصول من تحضير للأرض والتحكم في الري والتسميد المناسب ومكافحة الحشائش وغيرها.



إنتاج التقاوي عملية فنية تحتاج إلى المعرفة والمتابعة والدقة والاحلاص والأمانة...

## 6. إنتاج التقاوي:

- إنتاج التقاوي يحتاج إلى مراعاة عدد من الجوانب الفنية والتقيد بالشروط الفنية الصادرة من إدارة التقاوي ومنها:
- التأكد من مصدر التقاوي والحرص على الحصول على الشهادة للرتبة السابقة.
- التقيد بمسافات العزل المحددة لكل محصول والتأكد من أن المحصول السابق في الأرض المراد زراعتها لم يكن نجلياً مثل القمح والذرة.
- يجب التأكد من نظافة الزرّاعة عند الزراعة وكذلك الحاصدة عند الحصاد منعاً للخلط الميكانيكي.
- لتيسير عملية التنقية وإزالة الشوائب يفضل تقليل معدل التقاوي عن المعدلات الموصى بها في الزراعة العادية.
- عمل التنقية اليدوية للسنابل الغربية عن الصنف المقصود إكثاره وإقتلاعها مع كل خلفها.



الطريقة المثلى للزراعة هي التي تضمن وضع البذور في عمق مناسب والتوزيع الجيد للبذور في الرقعة المراد زراعتها ...

## 7 طرق الزراعة:

- الطريقة المثلى لزراعة القمح ينتج عنها وضع البذور داخل التربة بعمق 5-7.5 سم وإلى توزيع البذور بالتساوي في الرقعة الزراعية المستهدفة.
- يستحسن أن تكون الزراعة بالزراعة (السطارة) على سطور تتباعد عن بعضها البعض بمسافة 20 سم.
- في حالة عدم توفر السطارة يمكن إستعمال الدسك العريض شريطة مراعاة عمق الزراعة او النثر ثم التسريب.
- لتحقيق تأسيس جيد يمكن القيام بالزراعة بعد التروية، الزراعة على اللين، الزراعة والتسريب الخفيف بالبلنجة على بعد 40 سم او الزراعة على السطح في تربة ناشفة شريطة مراعاة التسوية الجيدة.
- الزراعة على المساطب 80 سم بالآلة (3 صفوف) تسهل عملية الري وتمنع الغرق وتساعد في تقليل معدل التقاوي.
- في كل الحالات يجب الحرص على تقسيم الحقل (الحواشة) إلى جداول وتقانات لتسهيل عملية الري.
- في حالة عدم التحضير الجيد للأرض يفضل زيادة عدد الرباطات أو التسريب الخفيف للتحكم في علمية الري.



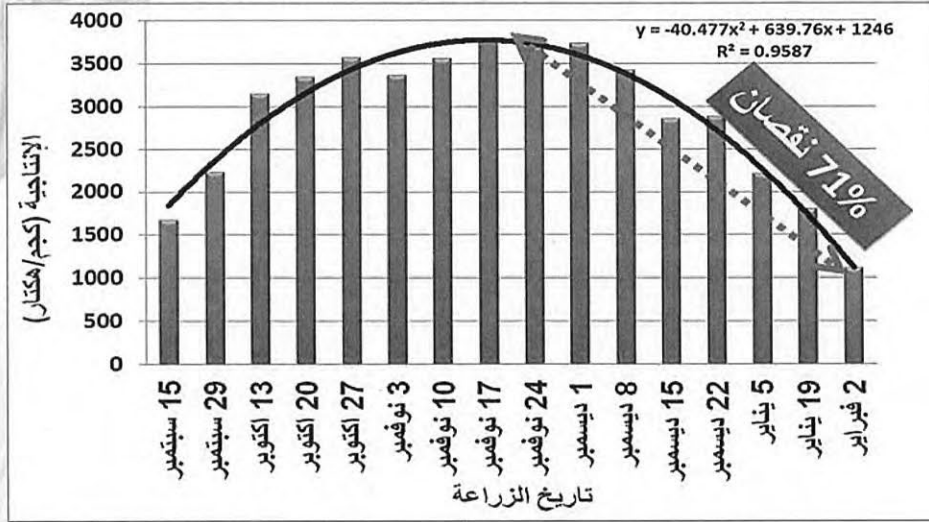
## 8. موقيت الزراعة:

- أنسب تاريخ لزراعة القمح في السودان هو الذي يجعل فترات النمو الحرجة للنبات (تكوين السنابل، الإزهار، وتكوين وإمتلاء الحبوب) تتزامن مع أكثر الفترات برودةً أثناء الموسم (ديسمبر - يناير - فبراير).
- إرتفاع درجات الحرارة في فترة النمو الخضري يؤدي إلى سرعة الإزهار وتكوين سنابل صغيرة وقليلة العدد كما أن إرتفاعها أثناء الإزهار يؤدي إلى ضعف الإخصاب وعدد قليل من الحبوب وإرتفاعها أثناء تكوين الحبوب ينتج عنه حبوب ضامرة.
- تختلف درجة تحمّل الإجهاد الحراري في بداية الموسم من صنف إلى آخر. عموماً الأصناف متأخرة النضج أكثر تحملاً للحرارة في بداية الموسم مقارنة بالأصناف مبكرة النضج. لذا لا يُنصح بزراعة الأصناف المبكرة قبل النصف الأول من شهر نوفمبر.
- المدى الزمني الأمثل لتاريخ زراعة القمح في السودان يمتد بين 3 نوفمبر إلى 12 ديسمبر ولكنه يختلف بإختلاف مناطق زراعة القمح وبإختلاف الأصناف. ففي وسط السودان تعتبر الزراعة خلال شهر نوفمبر هي الأمثل بينما تمتد الفترة في الولايات الشمالية حتى الثلث الأول من ديسمبر.
- يفضل زراعة القمح خلال الأسبوع الثاني والثالث من نوفمبر للأصناف المتأخرة النضج في وسط السودان.



## تأخير الزراعة قد يؤدي إلى تقليل الانتاجية بصورة كبيرة ...

- ويمكن الإستمرار في الزراعة حتى الأسبوع الأخير من نوفمبر بالنسبة للأصناف المتوسطة النضج.
- أما الأصناف المبكرة النضج فيمكن زراعتها في الفترة من الأسبوع الأخير من نوفمبر وحتى الأسبوع الأول من ديسمبر.
- أي تأخير عن المواعيد المذكورة أعلاه يؤدي لتقليل الإنتاجية بصورة مطردة. فمثلاً تأخير الزراعة إلى يوم 20 ديسمبر أدى إلى 55% فقدان في الإنتاجية وإلي أكثر من 71% عند تأخيرها إلى بداية فبراير بدلاً عن 20 نوفمبر (الشكل 2).



الشكل (2): أثر تاريخ الزراعة على إنتاجية القمح في ولاية نهر النيل  
المصدر: ابراهيم 1996

لضمان الاستفادة القصوى من التسميد لابد من إختيار السماد المناسب والتوقيت المناسب والتوزيع الجيد المتساوي في كل الرقعة المزروعة ...

## 9. التسميد

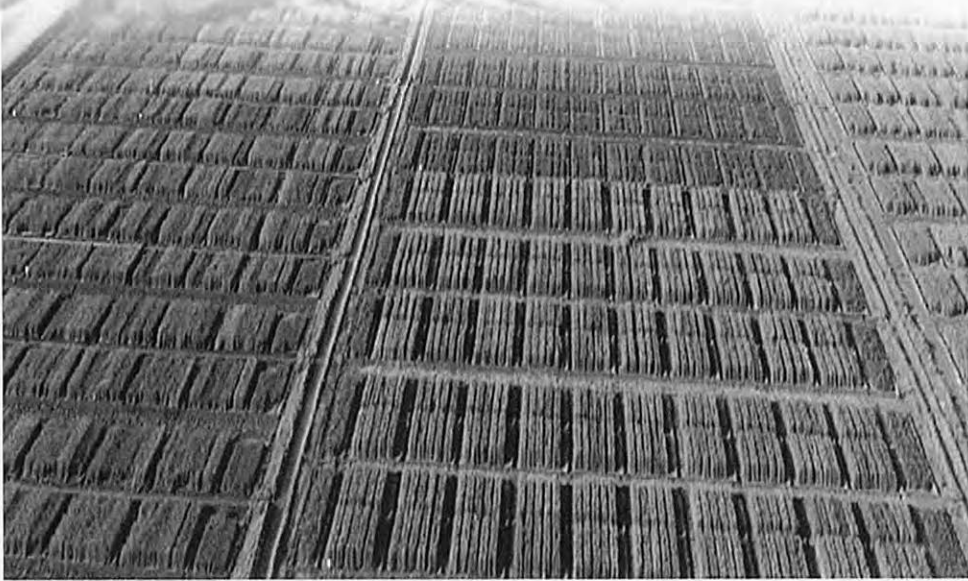
تختلف حاجة القمح للتسميد باختلاف أنواع الترب ولكن معظمها تحتوي على نسب ضئيلة من عنصري الأزوت (النيتروجين) والفسفور وهما من العناصر الرئيسية التي لا يمكن تحقيق إنتاجيات عالية واقتصادية دون إستخدامهما.

- هنالك العديد من مصادر الفسفور والنيتروجين ويعتمد الإختيار من بينها على عدة عوامل منها توفرها في الاسواق وأسعارها وطريقة وتوقيت وملاءمة إستخدامها وغيرها.
- التسميد بالفسفور:

- ◆ عند التوزيع الجيد والمتساوي للسماد، يحتاج القمح إلى 18 كجم أكسيد الفسفور/ الفدان {40 كجم من الفسفور الثلاثي السيوبر، (TSP) أو الداب (DAP) أو 32.5 كجم من فوسفات الأمونيوم الأحادي (الماب، MAP)}.
- ◆ يوضع السماد الفسفوري داخل التربة مع الزراعة عند إستعمال الزراعة أو قبل الدسك أو ينثر قبل الزراعة ويتم دفنه مع البذرة أثناء عملية الزراعة حرصاً على وضعه قريباً من البذور وذلك نسبة لبطء حركته وإمكانية تثبيته في التربة بسبب قلويتها العالية.
- ◆ عدم الإلتزام بوضع السماد الفسفوري في الموضع المناسب وتوزيعه الجيد في الحقل قد يقود إلى عدم الإستفادة المثلى منه وبالتالي اللجوء لزيادة لتوفير الإحتياج الحقيقي للمحصول.
- ◆ إضافة سماد الفسفور تزيد الإنتاجية بـ 25-50٪ في الأراضي التي لديها الإستجابة للفسفور.
- ◆ ليست هنالك إستجابة للتسميد بالفسفور في أراضي الجروف والجزر شمال الخرطوم. كما أن هنالك نتائج متباينة لأثر السماد الفسفوري على إنتاجية القمح في حلفا الجديدة وتحتاج إلى تأكيدها بإجراء بحوث مكثفة.

## تجنب تعريض سماد اليوريا لأشعة الشمس والرطوبة لتفادي فقدانه عن طريق التبخر ...

- ◆ لتقليل الفاقد من سماد اليوريا يجب الحرص على تطبيقه في نفس يوم الري وعدم تركه ليتعرض لأشعة الشمس والرطوبة لأن ذلك يؤدي إلى فقدانه عن طريق التبخر.
- ◆ يجب الحرص على التوزيع الجيد للسماد وأن تكون الريّة التي يطبق فيها السماد رية خفيفة، كما يجب تلافي الغرق والحرص على عدم تسرب مياه الري خارج الحقل.
- ويوصى بإضافة الأسمدة العضوية خاصة لأراضي التروس العليا في حدود 2-5 طن للفدان.
- بعض الأسمدة الورقية أعطت نتائج إيجابية لإنتاجية القمح عند إستخدامها مع الجرعة الموصى بها من النيتروجين والفسفور وتحت ظروف الإدارة الجيدة للمحصول رغم أن هذه النتائج غير ثابتة في كل المواقع ولذا لم تتم التوصية بها.



القمح حساس للعطش والغرق والمتابعة للصيقة تضمن سلامة المحصول...  
يجب الاهتمام الشديد بالري خاصة الريّة الأولى...

## 10 الري

- ترب السهل الطيني الأوسط طينية ثقيلة ذات نفاذية ضعيفة للمياه ولذلك تتعرض للغرق بسهولة.
- القمح لديه حساسية شديدة للمياه الزائدة (الغرق) أثناء الإنبات. عليه يجب الإهتمام الشديد بالري خاصة الريّة الأولى والثانية. وللمساعدة على ذلك يجب تقسيم الحواشة بعد زراعتها إلى أحواض أو رباطات، يتم ريهها بحرص شديد بحيث لا تكون هنالك أي مياه راكدة على السطح بنهاية يوم الري.
- ويوصى أن تكون الريّة الأولى خفيفة لتحقيق التأسيس الجيد والإسراع بالريّة الثانية في خلال 10-12 يوم من الريّة الأولى.
- إنتاجية القمح تتوقف على التأسيس الجيد للمحصول وأي خلل في التأسيس (وجود فراغات) يؤدي إلى إنتاجيات ضعيفة بسبب قلة عدد السنابل في وحدة المساحة المعينة. التأسيس الجيد يساعد على تقليل منافسة الحشائش للمحصول لأن وجود مساحات فارغة تشجع على نمو الحشائش والتي تنافس المحصول وتزيد من تكلفة الإنتاج بالحش اليدوي أو المكافحة الكيميائية.
- فترات الري تعتمد اعتماداً كبيراً على مراحل نمو المحصول، نوعية التربة وعلى درجات الحرارة السائدة أثناء الموسم. لذا يجب أن يتابع المزارع حقله بشكل شبه يومي لمعرفة الحاجة الفعلية للري دون التقيد بالفترات المذكورة أدناه.



المكافحة المتكاملة للآفات تقود إلى مكافحة فاعلة وآمنة لآفات الحشائش والحشرات والأمراض مع المحافظة على سلامة البيئة...

## 11. وقاية المحصول:

المكافحة المتكاملة للآفات:

- يجب إتباع نظام المكافحة المتكاملة للآفات عند التعامل مع كل الآفات التي تصيب محصول القمح والمحاصيل الأخرى.
- المكافحة المتكاملة للآفات هي عبارة عن نظام متكامل لإدارة الآفات يستخدم فيه كل طرق المكافحة المختلفة مثل الطرق الفلاحية، الحيوية، الميكانيكية، الكيماوية، التشريعية وغيرها في نظام مثالي يهدف إلى خفض أضرار الآفات والسيطرة عليها وبقائها دون الحد الإقتصادي الحرج للمعاملة أو التدخل الكيميائي مع المحافظة على سلامة البيئة.
- على سبيل المثال، استخدام الطرق الفلاحية بإتباع الدورة الزراعية المناسبة والتحضير الجيد للأرض في الوقت المناسب وتعفير البذور واستخدام الصنف المقاوم للأصداء يمكنها أن تؤدي إلى مكافحة فاعلة وآمنة للحشائش والحشرات والأمراض في محصول القمح.



التحضير الجيد للأرض والتأسيس الجيد للمحصول واتباع الدورة الزراعية المناسبة تقلل كثيراً من نمو الحشائش ...

أهم آفات القمح تتمثل في:

### 1.1 الحشائش:

- إذا تم تأسيس محصول القمح تأسيساً جيداً فإن ذلك يقلل من ظهور الحشائش بصورة ملحوظة.
- قد تنمو بعض الحشائش التي يمكن إزالتها بالرش بسهولة خلال 3-4 أسابيع من الإنبات (الشهر الأول من عمر المحصول) حيث أن تأخير الرش يؤدي إلى زيادة في حجم الحشائش وبالتالي صعوبة مكافحتها، يمكن استخدام المبيدات الحشائية المجازة حسب الجرعة الموصى بها مثل:
  - ◆ مركبات الـ D-4-2 لمكافحة الحشائش ذات الأوراق العريضة ويوجد العديد منها، تختلف جرعة المبيد حسب التركيز وتتراوح بين 830 سي سي (ملييلتر) للفدان للمبيدات التي تركيزها 60% و1000 سي سي للفدان للمبيدات ذات التركيز 72%. يجب تطبيق عملية رش المبيدات في المواعيد الموصى بها خاصة مبيدات الـ D-4-2 لأن تأخير الرش قد يؤدي لتشوهات في السنابل.
  - ◆ مبيدات مكافحة العذار والشوفان والحشائش النجيلية الأخرى مثل البوما او التوبيك أو التراكسوس والتيردوك والتوب نور وغيرها. الجرعة لأغلب هذه المبيدات هي 420 سي سي للفدان.



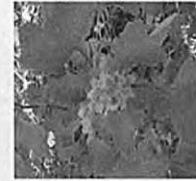
فجيلة



عذار



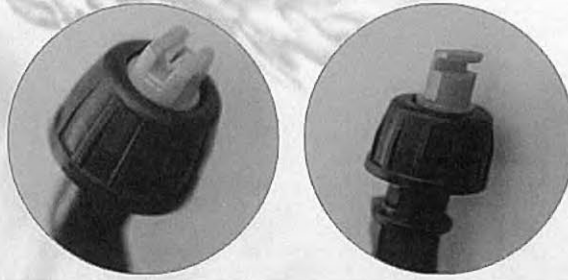
قبر



رامتوك

اختيار المبيد المناسب والبشور الصحيح والرش في الفترات الصباحية أو المسائية  
تزيد كثيرا من فاعلية مبيدات الحشائش...

- يجب استخدام البشور (الفونية) الصحيح لضمان التغطية الكاملة للحشائش بالمبيد وذلك لضمان فاعليته.
- لضمان فاعلية المبيد يجب تجنب الرش في حالة عطش المحصول وكذلك يجب تجنب الرش في حالات الرياح الشديدة.
- يوصى بالرش في الفترات الصباحية أو المسائية وتجنب الرش في فترة الظهيرة حتى يتم إمتصاص المبيد من قبل الحشائش المستهدفة. كما يوصي بعدم الري مباشرة بعد الرش ويستحسن ترك المبيد لمدة لا تقل عن 6-12 ساعة لكي تكتمل عملية الإمتصاص.
- عند تواجد الحشائش عريضة الأوراق والنجيلية مثل العدار فيمكن المكافحة بخلط مبيدات معينة مع بعضها مثل خلط التوبيك مع الديالين سيوبر بجرعة 420 سي سي من التوبيك و380 سي سي من الديالين سيوبر للفدان. وكذلك يمكن خلط التوبيك مع الجنتان بجرعة 420 س س من التوبيك و3 جرام من الجنتان للفدان الواحد.
- هنالك بعض المبيدات ذات أثر مزدوج للحشائش عريضة الأوراق والنجيلية تمت التوصية بها حديثاً مثل أتلانتس ((Atlantis بجرعة 525 سي سي للفدان.

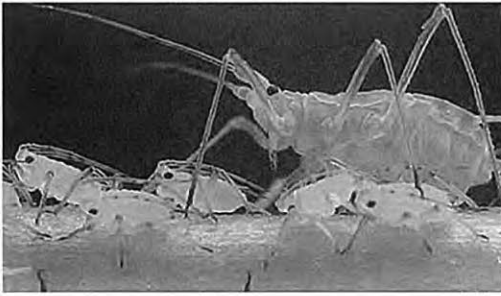


شكل البشابير المستخدمة لتطبيق مبيدات الحشائش

التعفير الجيد للتقاوي بالمبيدات الموصى بها يقلل كثيراً من مخاطر الإصابة بالآفات خاصة في مراحل النمو الأولى...

## 2.11 الحشرات:

- يصاب القمح بعدد من الحشرات والآفات أهمها حشرة المن، ثاقبات الساق، حافرات الأنفاق، النمل الأبيض (الأرضة) بالإضافة إلى بعض الآفات القومية مثل الفأر والطيور والجراد.
- حشرة المن تعتبر من أهم الحشرات التي تؤثر تأثيراً إقتصادياً على محصول القمح. وتقل الإصابة عند تعفير التقاوي بالمبيدات الموصى بها بصورة كبيرة، وإذا حدثت الإصابة ووصلت للحد الإقتصادي الحرج للرش (35% من النباتات مصابة) فيمكن معالجتها بالرش بمبيدات مجازة وفعالة.
- يوصى بتعفير التقاوي بمبيدات الحشرات والفطريات بالمعدلات الموصى بها.
- مبيدات الحشرات الموصى بها تشمل مجموعة الإמידاكلوبريد (Imidacloprid) مثل القاوشو والقوليش (تستخدم بمعدل 0.5 جم (س س) من القاوشو لكل كيلوجرام من التقاوي). أما مبيدات الفطريات فتشمل مجموعة التيوبكونازول (Tubconazol) مثل الراكسيل (تستخدم بمعدل 1.5 جم من الراكسيل لكل كيلو من التقاوي).
- هنالك بعض معفرات البذور تحتوي على المبيدات الحشرية والفطرية معاً مثل السيليستوب (Celest Top) وغيرها.



## تأكد من الحصول على المبيدات المناسبة من مصادرها الموثوقة...

- معظم معفرات البذور تعطي حماية للمحصول من آفات العسلة والأرضة لفترة تتراوح بين 45-60 يوم مما يقلل من تطبيق المبيدات السائلة بالرش الجوي.
- في حالة معاملة البذور بالمعفرات يجب الحرص على الحصول عليها من المصادر الموثوق بها والإلتزام بإتباع إجراءات السلامة عند التعفير.
- هنالك بعض الأعداء الطبيعية مثل أبو العيد تساعد كثيراً في القضاء أو التقليل من الإصابة بحشرة المن.
- أيضاً يتأثر القمح ببعض الآفات الثانوية مثل ثاقبات الساق ولكن حتى الآن لا تعتبر من الآفات الاقتصادية.
- أما الآفات القومية فتتم إدارتها والسيطرة عليها من قبل الإدارة العامة لوقاية النباتات المركزية أو الولائية.



اختيار الصنف المقاوم لأمراض الصدأ هو أنسب وسيلة لتجنب الإصابة بها في منطقة حلفا الجديدة ...

### 3.11. الأمراض:

- أمراض الصدأ (صدأ الساق الأسود وصدأ الأوراق) هي من أهم الأمراض التي تؤثر إقتصادياً على محصول القمح.
- يتركز إنتشار هذه الأمراض في منطقة حلفا الجديدة نسبة لملائمة المناخ (الرطوبة العالية ودرجات الحرارة).
- زراعة الأصناف المقاومة لهذه الأمراض هي الوسيلة الأمثل لتلافي آثارها السالبة وقد تصل نسبة فقدان المحصول إلى 70% عند زراعة الأصناف الحساسة لهذه الأمراض.
- هنالك عدد من الأصناف المقاومة لهذه الأمراض تمت إجازتها مثل أمل، الشيبك، جواهر، صلاح وخديوي.
- تمت إجازة المبيد الفطري برايبوري أكسترا (Priori Xtra 280 SC) لمكافحة أمراض الصدأ بمعدل 200 سي سي للفدان ترش على مرتين: عند ظهور المرض وبعد أسبوعين لاحقاً.



التأخير في الحصاد وعدم التأكد من سلامة الحاصدة وكفاءتها قد تؤدي إلى فقدان كبير في إنتاجية المحصول ...

## 12. الحصاد وعمليات ما بعد الحصاد

- يكون القمح جاهزاً للحصاد عندما تجف النباتات ويكون من السهل كسر الساق وفصل البذور عن السنابل.
- التأخير لأكثر من 4 أسابيع من هذا التاريخ يؤدي لفقد كبير في الإنتاجية قد يصل إلى 30% من الإنتاج نتيجة تفرط البذور.
- يجب الحرص على أن تكون الرية الأخيرة خفيفة لتفادي رقاد المحصول ونمو الحشائش التي قد تعيق عملية الحصاد الآلي.
- يجب الحرص على كسر التقانن والجداول قبل بدء عملية الحصاد وذلك لتقليل الفاقد والحرص على سلامة الحاصدات.
- يجب التأكد من سلامة الحاصدة وكفاءتها وضبطها قبل البدء في عملية الحصاد.
- من الضروري جداً التحكم في سرعة الحاصدة أثناء الحصاد لأن السرعة الزائدة تؤدي إلى فقدان نسبة مقدره من المحصول.
- في حالة تخزين المحصول أو التقاوي، يجب التأكد من التخزين الجيد في مخازن ذات تهوية جيدة ومراعاة درجات الحرارة والرطوبة المناسبة للتخزين.
- يراعى استخدام المبيدات الموصى بها وبالطرق الصحيحة عند مكافحة الكيمائية لآفات المخازن مع مراعاة فترة الأمان للمبيدات المستخدمة.



باختيار الصنف المناسب والادارة الجيدة للمحصول خاصة التسميد يمكن الحصول على نوعية جيدة للحبوب ...

### 13. نوعية الحبوب (الجودة)

- أهم ما يميز حبوب القمح عن المحاصيل الأخرى هو إحتوائها على مادة البروتين والقلوتين والتي تكسب العجين صفتي اللزوجة والمرونة.
- من أهم العناصر التي تحدد جودة حبوب القمح هي درجة صلابة وكثافة الحبوب، نسبة إستخلاص الدقيق، كمية ونوعية البروتين ونسبة ونوعية القلوتين. رغم أن كل هذه الصفات تحدد وراثياً في الصنف المعين لكنها تتأثر بدرجات متفاوتة بالعوامل البيئية والعمليات الفلاحية المختلفة.
- التسميد ودرجات الحرارة هما من أكثر العوامل تأثيراً على نوعية الحبوب.
- درجات الحرارة العالية في نهاية الموسم تؤدي غالباً إلى زيادة كمية البروتين في الدقيق لكنها في المقابل تؤدي إلى نقصان قوة ومقاومة العجين للخلط.
- بعض الأصناف السودانية تحمل في تراكيبها الجينية وحدات جزيئية مرغوبة من البروتين والقلوتين والتي تحدد إلى درجة كبيرة جودة دقيق القمح وإستعملاته. مثال لذلك إمام، ساساريب، زكية وعجيب.
- لوحظ أن هنالك تدنى في نسبة البروتين والقلوتين الرطب عند إختبار عينات قمح أخذت من حقول مزارعين مقارنة مع عينات أخذت من محطة بحوث الجزيرة. يرجع ذلك غالباً لعدة عوامل أبرزها عدم إستعمال تقاوي نقية من الصنف المعين وعدم الالتزام بالعمليات الفلاحية وخاصة التسميد بالازوت ونظافة الحشائش.



## تختلف جودة أصناف القمح باختلاف الاستخدام النهائي للحبوب ...

- زراعة الصنف المناسب في التاريخ المناسب مع التطبيق الجيد للتقانات ستؤدي إلى إنتاج نوعية جيدة من حبوب القمح من أصناف مثل دبيرة، ساسريب، إمام، زكية وعجيب، الخ.
- تختلف الجودة المطلوبة في القمح باختلاف الاستخدام النهائي فمثلاً هنالك أصناف تصلح لصناعة الخبز بينما أخرى يفضل استخدامها دقيقتها لعمل البسكويت والخبائز والقراصة وغيرها.
- إضافة السماد الأزوتي والكبريت بعد الإزهار تحسّن نوعية القمح ولكنها قد لا تؤدي لزيادة في الإنتاجية.



الإدارة المتكاملة للحقل والاهتمام بتطبيق الخيارات التقنية تؤدي إلى تحقيق عائد مجزي من محصول القمح ...

## 14. إقتصاديات إنتاج القمح:

نسبة للتفاوت الكبير في قيمة الجنيه السوداني فقد تم حساب تكلفة زراعة القمح بالعائد من المنتج (كجم قمح)، هذه الطريقة ربما تساعد في تحديد أسعار القمح مستقبلاً بالأخذ في الإعتبار تكلفة الإنتاج والعائد من المنتج.

• التكلفة الكلية لفدان القمح في المشاريع المروية تتراوح غالباً بين العائد من 5-7 جوال (0.5-0.7 طن) من المنتج اعتماداً على أسعار المدخلات والقمح. يعني ذلك أن الأرباح من إنتاج -1214 جوال (1.2-1.4 طن للفدان) تعادل أكثر من 100% من التكلفة. وإذا أخذنا في الإعتبار أن عدداً مقدراً من المزارعين ينتجون أكثر من 16 جوال للفدان (1.6 طن للفدان) فإن العائد من القمح لدى هؤلاء المزارعين هو حوالي 150% من التكلفة في خلال 4-5 شهور.



نسبة العائد الى التكاليف: كلما زادت الانتاجية الرأسيية زادت نسبة العائد من القمح وقد تصل إلى أكثر من 200 % من التكاليف ...

التكلفة الكلية لزراعة فدان القمح والإنتاجية والعائد المتوقع حسب تكلفة مدخلات الإنتاج والسعر التركيبي للقمح في موسم 2019 / 2020

تكلفة الفدان (كجم قمح )			
البيبان	الشمالية ونهر النيل	الجزيرة وحلفا الجديدة	النيل الأبيض
التحضير (الأول والثاني)	40	35	40
الزراعة بالآلة	10	10	7
التقاوي 60 كجم/الفدان	80	80	80
السماذ	140	140	140
مبيد الحشائش ( العريضة والنجبية)	35	35	35
نثر السماذ و رش المبيدات	10	10	10
الإشراف الإداري والفني	10	8	8
الحصاد الآلي	40	35	35
الخيض	55	50	50
خدمات الإدارة ومياه الري	45	40	40
الزكاة	65	60	60
التأمين الزراعي	10	10	10
تكلفة الري ( 8 ريات)	60	50	60
الجهد العام للمزارع	30	30	30
جملة التكلفة (كجم للفدان)	630	593	605
جملة التكلفة (بالجنيه حسب أسعار 2020)	22050	20755	21175
متوسط إنتاجية الفدان (كجم)	1300	1200	1200
جملة العائد (بالجنيه حسب أسعار 2020)	45500	42000	42000
صافي الإنتاج للفدان الواحد (كجم)	670	607	595
صافي الأرباح للفدان (بالجنيه حسب أسعار 2020)	23450	21245	20825
نسبة العائد إلى التكاليف	2.06	2.03	1.98

التحسين الوراثي، الكفاءة الانتاجية، تخفيض تكلفة الانتاج والاهتمام  
المتكامل بسلسلة قيمة القمح هي الضمان لاستدامة زراعة القمح في السودان...

## مستقبل زراعة القمح في السودان

- على الرغم من الزيادة المضطربة في إنتاج وإنتاجية القمح في السودان مؤخراً فإن إستهلاك القمح يزداد بوتيرة أكبر مما زاد من إستيراده لسد الفجوة.
- ولأن إستيراد القمح يفرض عبئاً كبيراً على الاقتصاد السوداني فإن سد الفجوة بين الإنتاج والاستهلاك يتطلب زيادة الإنتاج المحلي من خلال زيادة الإنتاجية لكل وحدة مساحة إلى جانب التوسع الأفقي. ولتحقيق ذلك يجب أن تتضمن الخطة المستقبلية الآتي:
  - تحسين القمح من خلال تطبيق التقنيات التقليدية والحديثة لملائمة التغيرات المناخية وتطوير أصناف مقاومة للحرارة ونقص المياه وذات كفاءة عالية في استخدام المغذيات وتحسين القيمة الغذائية وجودة الاستخدام النهائي للقمح.
  - إستغلال وإكمال الطاقة الإنتاجية الحالية في المشروعات الزراعية القائمة وإعادة تأهيلها لزيادة كفاءتها.
  - توسيع مناطق إنتاج القمح، وخاصة في الامتدادات الجديدة للمشروعات القائمة والتوسع الأفقي في مناطق إنتاج جديدة والاستخدام الأمثل للموارد الطبيعية بما في ذلك مخزون المياه الجوفية
  - تخفيض تكلفة الإنتاج وزيادة القدرة التنافسية لمحصول القمح.
  - الإهتمام بسلسلة القيمة وتقوية نقاط الضعف فيها (عمليات ما بعد الحصاد، الجودة، التخزين، وغيرها) وتكوين المجالس السلعية (مجلس سلعة القمح).
- وفي ظل التغيرات المناخية وما يصاحبها من آثار ضارة متوقعة لإنتاج القمح مثل إرتفاع درجات الحرارة، لابد من دراسات تحليلية شاملة تساعد في تطوير وتوفير سيناريوهات ونماذج بديلة لإنتاج القمح في السودان تلائم هذه التغيرات المتوقعة وكذلك تطوير وإستنباط تقانات إنتاج قمح صديقة للبيئة وتلائم التغيرات المناخية.
- تعمل هيئة البحوث الزراعية في السودان بالتعاون مع بعض المؤسسات الوطنية والمنظمات البحثية والجامعات العالمية في وضع سيناريوهات لإنتاج القمح في السودان مستقبلاً تلائم التغيرات المناخية المتوقعة.

### مشروع تقانات مبتكرة لإنتاج مستدام للقمح (تمام)

• أهداف المشروع: زيادة إنتاج القمح وإنتاجيته في السودان لتحقيق الاعتماد على الذات من خلال تسريع عملية تحسين القمح لملائمة التغيرات المناخية، وضع سيناريوهات ونماذج بديلة لإنتاج القمح تلأئم التغيرات المناخية، تطوير وتنفيذ خطط إنتاج التقاوي، نشر التقانات والابتكارات باتباع منهجية منصات الابتكار والمنصات الرقمية وبناء القدرات لجميع أصحاب المصلحة على طول سلسلة قيمة القمح.

• الجهات المنفذة: هيئة البحوث الزراعية بالتعاون مع الهيئة العامة للأرصاء الجوية السودانية وجامعة توتوري بالتعاون مع جامعة تسوناميا في اليابان.

• الجهات الممولة: الوكالة اليابانية للعلوم والتكنولوجيا، الوكالة اليابانية للتعاون الدولي وحكومة السودان (المكون المحلي).

هيئة البحوث الزراعية - برنامج بحوث القمح - أكتوبر 2020

### للاستفسار

تلفونات:



المهندس لخرمات الطباعة  
0129370910



مشروع تقانات مبتكرة لإنتاج مستدام للقمح (تمام)

هيئة البحوث الزراعية  
برنامج بحوث القمح بالتعاون مع  
جامعة توتوري في اليابان



الخيارات التقنية لإنتاج مستدام للقمح  
في السودان



هيئة البحوث الزراعية

برنامج بحوث القمح بالتعاون مع جامعة توتوري في اليابان

مشروع تقانات مبتكرة لإنتاج مستدام للقمح

(تمام)

الخيارات التقنية لإنتاج مستدام للقمح

في السودان

## مشروع تقانات مبتكرة لإنتاج مستدام للقمح (نعام)

### مقدمة

يعد القمح من أهم محاصيل الأمن الغذائي في العالم و هو من أكبر مصادر البروتين النباتي للإنسان. يعتبر القمح من محاصيل المناطق الباردة ومعتدلة المناخ مما جعل زراعته تقليدياً تنحصر في المناطق الباردة نسبياً في شمال السودان (شمال خط عرض 17° شمالاً). القمح محصول قديم في السودان قدم الحضارة النوبية حيث يحمل إسماً نوبياً مثله مثل الذرة والشعير والنخيل وغيرها.

نسبة للزيادة المضطربة في إستهلاك القمح كان لا بد من التفكير في التوسع في زراعته جنوباً إلى السهول الطينية حتى خط عرض 13° شمالاً (الجزيرة، الرهد، حلفا الجديدة، النيل الأبيض، السوكي ومشاريع النيل الأزرق). أهم التحديات التي واجهت ذلك التوسع هو إستنباط الأصناف المناسبة التي تتحمل الإجهاد الحراري بالإضافة إلى إيجاد التقانات المناسبة التي تمكن المحصول من تجاوز غلواء الإجهاد الحراري في تلك المناطق.

لمواجهة هذه التحديات تمكنت هيئة البحوث الزراعية من إستنباط أصناف قمح ذات إنتاجيات عالية ولها القدرة على الملائمة والتأقلم مع درجات الحرارة المرتفعة بالإضافة إلى إستحداث التقانات المناسبة لزراعة القمح تحت ظروف الإجهاد الحراري مما أدى إلى التوسع في زراعته.



القمح من المحاصيل المتأقلمة لبيئات مختلفة، ولذا يجب مراعاة متطلبات كل بيئة للحصول على إنتاجية عالية...

## بيئات إنتاج القمح في السودان:

- بيئات إنتاج القمح في السودان تتفاوت تفاوتاً كبيراً ومؤثراً من حيث المناخات السائدة والتنوع في التربة وعوامل الإنتاج الأخرى مما قد يستوجب التعامل مع كل بيئة بخيارات تقنية مختلفة.
- التباين في المناخ يتمثل في درجات الحرارة والرطوبة النسبية السائدة خلال الموسم حيث ترتفع درجات الحرارة تدريجياً كلما إتجهنا من الشمال إلى الجنوب فنجد أن مناطق شمال السودان أكثر برودة من أواسط وشرق السودان.
- تمثل وجود رطوبة نسبية عالية في منطقة حلفا الجديدة مقارنة بباقي مناطق زراعة القمح بيئة مناسبة لبعض الأمراض خاصة أمراض الصدأ (صدأ الساق والأوراق) مما يستوجب إختيار الأصناف المقاومة لهذه الأمراض في تلك المنطقة.
- الاختلاف في التربة بين بيئات زراعة القمح في السودان يتمثل في التباين في خواصها الفيزيوكيميائية والمورفولوجية حيث تختلف أراضي الرسوبيات الحديثة (أراضي الجروف) عن أراضي الكرو والتروس العليا في شمال السودان.
- الإختلاف في الخواص الفيزيوكيميائية يتمثل في قوام التربة (نسبة الطين) وقلويتها ومدى تأثرها بالأملاح ومحتوياتها من العناصر المغذية مما يستوجب معالجات معينة في حال وجود معيقات مرتبطة بتلك الخواص.
- الإدارة الجيدة لمحصول القمح وبكل ما ذكر من تنوع في البيئات تستوجب إدارة رشيدة لعمليات تحضير التربة، الري والتسميد من حيث الطرق المطلوبة وتوقيتها وفترات الري وجرعات السماد الموصى بها.

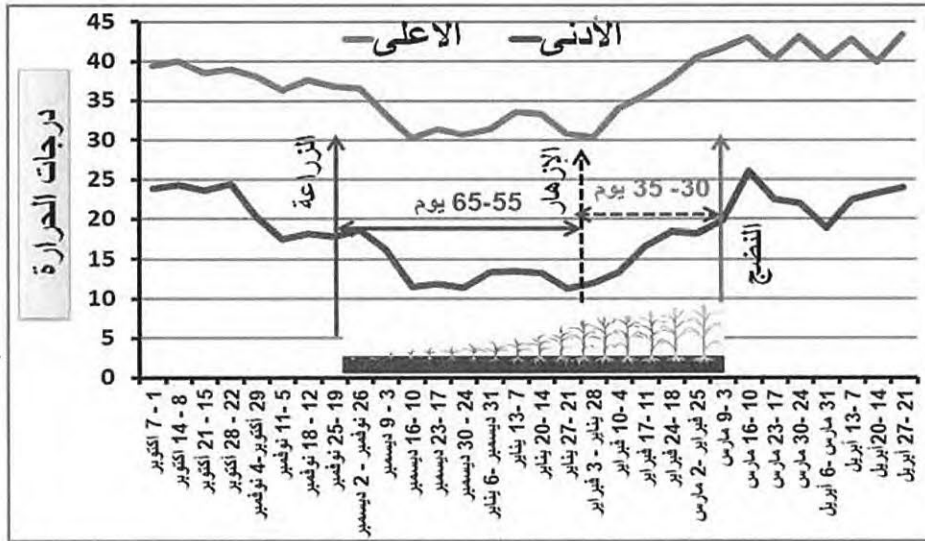


الإهتمام والالتزام بتطبيق تقانات انتاج القمح يحد من آثار الاجهاد الحراري ويؤدي إلى الحصول على انتاجيات عالية ومربحة ...

### الخيارات التقنية لإنتاج مستدام للقمح:

نسبة لقصر الموسم الزراعي للقمح في السودان وإرتفاع درجات الحرارة (الشكل 1)، يتحتم على المنتج الإهتمام والإلتزام بتطبيق كافة التقانات الخاصة بإنتاج القمح وذلك للحد من آثار الإجهاد الحراري والحصول على إنتاجيات عالية وبالتالي عائد إقتصادي مجزي من محصول القمح.

الهدف الرئيسي لهذا الكتيب هو عرض الخيارات التقنية المناسبة لكل مناطق إنتاج القمح في السودان من أجل إنتاج مستدام ومجزي.



الشكل (1): درجات الحرارة الأسبوعية في ود مدني إبتداء من الأول من أكتوبر

لضمان انتاج مريح ومستدام يوصى باتباع نظام الادارة المتكاملة للمحصول  
والاستخدام الأمثل للمدخلات والمتابعة اللصيقة للمحصول في كل مراحل نموه...

## موجهات هامة

يتميز القمح عن أغلب المحاصيل الحقلية الأخرى في السودان بسهولة زراعته وإدارة حقله وذلك لأن معظم العمليات الفلاحية تتم بإستخدام الآلات الزراعية مع الإعتماد على عدد قليل من الأيدي العاملة. ولكن هنالك موجهات هامة يجب إتباعها:

• لتحقيق إنتاج مريح ومستدام لمحصول القمح في ظل ظروف الإجهاد الحراري في السودان يوصى دائماً بإتباع نظام الإدارة المتكاملة للمحصول (Integrated Crop Management, ICM)، الإدارة المتكاملة للمحصول هي التي تراعي سلسلة القيمة الكاملة بما في ذلك إتباع الدورة الزراعية المناسبة، والتنوع المناسب للمحاصيل، والتطبيق المناسب وفي الوقت المناسب لمختلف الممارسات الزراعية (مثل إدارة التربة والمياه، وتغذية المحاصيل، وإدارة الآفات، إلخ...) والعوامل الاجتماعية والإقتصادية والبيئية والتي يمكنها أن تخفف من التأثير السلبي للإجهاد الحراري على غلة المحصول والنوعية للإستخدام النهائي.

• تتكامل كل الخيارات التقنية لزراعة القمح لبلوغ الإنتاجية المرجوة. لذلك فإن الإخلال في التطبيق الصحيح لأي منها قد يؤدي الى فقدانك قدراً كبيراً من الإنتاج وبالتالي الربحية.



لحفاظ على صحتك وعلى البيئة يجب الالتزام بإجراءات السلامة عند استخدام المبيدات...

- استخدام أي مدخل أو تقانة من تقانات إنتاج القمح يجب أن يكون مرتبطاً بالعائد أو الجدوى الاقتصادية من استخدامه، مثلاً إذا كانت الزيادة في الإنتاجية لا تغطي تكلفة السماد الزائد فلا داعي للزيادة في استخدامه إلا لأغراض أخرى مثل إنتاج التقاوي.
- التفريط أو الإفراط في استخدام المدخلات المختلفة مثل الأسمدة والمبيدات والري والحرث المتكرر غير الضروري لديه تأثير مباشر على الإنتاج الاقتصادي المربح وربما يضر بالإقتصاد القومي.
- عند استخدام وتطبيق المبيدات يجب مراعاة لبس الملابس الواقية والكمادات والقفازات للحماية من التعرض للسموم. عدم إتباع الإرشادات في استخدام المبيدات يسبب ضرراً مباشراً لصحتك وللبيئة.
- الإخلال في تطبيق كل الخيارات التقنية بالصورة الصحيحة يؤدي الي فقدان نسبة مقدرة من الإنتاج وبالتالي الربحية المرجوة. وهذا يظهر جلياً في التباين الكبير بين المزارعين في المنطقة الواحدة بل في النمرة الواحدة.
- في المقابل عند التطبيق الصحيح لكل الخيارات التقنية فإن عدد كبير من المزارعين في مناطق مختلفة من السودان قد حققوا إنتاجيات عالية فاقت 20 جوال للفدان (2 طن للفدان) بل إن بعض المزارعين حققوا أكثر من 28 جوال في الجزيرة وأكثر من 34 جوال في الشمالية.



اتباع الدورة الزراعية المناسبة يعتبر من أهم عناصر الحفاظ على الموارد الطبيعية...

لذا يجب الحرص على تطبيق التقانات تطبيقاً صحيحاً ومتابعة تطبيقها ميدانياً لأن ذلك من شأنه أن يساهم في رفع الإنتاجية والربحية وسط الغالبية العظمى من المزارعين في السودان وبالتالي المساهمة الفاعلة في الأمن الغذائي القومي. ويمكن تلخيص تقانات إنتاج القمح في السودان كالآتي:

### 1. الالتزام بالدورة الزراعية:

- إتباع الدورة الزراعية المناسبة من أهم عناصر الحفاظ على الموارد الطبيعية وخاصة الأرض وبالتالي الزراعة المستدامة.
- لا يوصى بزراعة محصول القمح عقب أي محصول نجيلي (ذرة، ذرة شامي، دخن، قمح، إلخ) وذلك لحماية التربة من الإنهك وللتقليل من مخاطر الآفات والأمراض وتأثير الحشائش النجيلية والخبثية مثل العدار الذي يصعب مكافحته يدوياً وتشكل المكافحة الكيميائية زيادة مقدرة في تكلفة الإنتاج.
- يستحسن زراعة محصول القمح عقب محاصيل غير نجيلية مثل القطن والبقوليات والخضروات وغيرها.



خلق المهد الجيد للمحصول من خلال إتباع إرشادات تحضير الأرض بشكل اللبنة الأولى للنجاح...

## 2. تحضير الأرض:

- يعتبر الاهتمام بتوفير المهد الجيد للبذور والخالي من الحشائش من أهم مقومات نجاح إنتاج القمح، ولكي نتحصل على مهد مستو وذو نعومة جيدة والتي تساعد على زراعة القمح بالآلة بكفاءة عالية يوصى بإتباع الخطوات التالية:
- الحرث المبكر أثناء الخريف بالطراد أو الخلخال أو بالدسك هرو في نهاية أغسطس / أوائل سبتمبر وذلك للإستفادة من رطوبة الأرض وكسر صلابتها وإزالة الحشائش قبل نضوج بذورها وكذلك لتهيئة التربة لإمتصاص أكبر قدر ممكن من الماء يساعد في إعدادها وريها مستقبلاً.
  - في المناطق التي لا توجد بها أمطار مثل الشمالية ونهر النيل يوصى بعمل تروية خلال النصف الثاني من أكتوبر (إن أمكن) وذلك للمساعدة في إنبات الحشائش وتوفير رطوبة مقبولة في التربة تساعد على التحضير الجيد للأرض وإنسياب الريّة الأولى للقمح.



## يوصى باستخدام التسطيح بالليزر في الأراضي التي تعاني من مشاكل التسوية...

- الحرث الثاني للأرض بالدسك هرو أو أي آلة شبيهة عندما تسمح رطوبة التربة بذلك في سبتمبر / أكتوبر بغرض تنعيم التربة وضمان توفير المهد الجيد.
- وبعد ذلك تتم تسوية الأرض باستخدام الآلة المناسبة (الكمرة، مربع قلوبال، الزحافة، الخ...) وذلك لردم الأماكن المنخفضة وإزالة المرتفعة منها.
- إن إقتضت الضرورة يمكن عمل التسطيح بالليزر حيث أن عملية التسوية هي التي تساعد على الإدارة الجيدة لمياه الري وإنسيابها وتفادي الغرق خاصة أثناء الري الأولي.
- يجب تجنب استخدام الدسك 3 صاجة إلا في الأراضي الموبوءة بالحشائش المعمرة (مثل النجيلية والسعدة) لأنه يتسبب في إحداث مجاري وأخاديد في الحقل مما يؤثر سلباً على عملية الري والإنبات.



إختيار الصنف المناسب لكل موقع والحصول على التقاوي من مصادرها الموثوقة هو الأساس لنجاح المحصول والحصول على الانتاجية الوفيرة...

### 3. الأصناف الموصى بها:

- هنالك العديد من الأصناف التي أجيّزت لزراعتها في مناطق إنتاج القمح في السودان، كل الأصناف المجازة لديها القدرة على تحمل الإجهاد الحراري ولكن بدرجات متفاوتة حسب مراحل نمو المحصول.
- يوصى بزراعة الأصناف التي أستنبطت في هيئة البحوث الزراعية وأجيّزت بواسطة اللجنة القومية للأصناف والتي يمكن تقسيمها إلى ثلاث مجموعات:
  - 1.3 أصناف متأخرة النضج نسبياً مثل إمام، تقانة، أرقين، زكية، عجيب وعكاشة ويفضل زراعتها خلال الأسبوع الثاني والثالث من نوفمبر ويجب تفادي زراعتها عندما تتأخر الزراعة عن المواعيد الموصى بها لأي سبب من الأسباب.
  - 2.3 أصناف متوسطة النضج مثل وادي النيل، دبيرة، النيلين، خليفة، خديوي وتزرع خلال الاسبوع الثالث والرابع من نوفمبر.
  - 3.3 أصناف مبكرة النضج نسبياً مثل بوهين، نبتة، قمرية، أمل، جواهر، صلاح، الشبيك وأشري (تزرع في الأسبوع الأخير من نوفمبر وحتى الأسبوع الأول من ديسمبر في الولايات الشمالية).
  - 4.3 هنالك أصناف ليست لديها مقاومة لأمراض الصدأ مثل النيلين، وادي النيل، أمام وتقانة ولذلك لا يوصى بزراعتها في حلفا الجديدة إلا عند توفر المبيد الموصى به لمكافحة هذه الأمراض.
  - 5.3 تمت التوصية بزراعة عدد من أصناف القمح القاسي (الديورم) في السودان مثل شام1-، أرقو، زيداب، بساتنة وود البر ويفضل زراعتها خلال الأسبوع الثاني إلى الرابع من نوفمبر.



الاعداد الجيد للتقاوي يؤدي الى التخلص من البذور الضامرة والمكسورة وبذور الحشائش الضارة والشوائب الأخرى...

#### 4. إعداد التقاوي:

- دور التقاوي محوري في تحديد إنتاجية المحاصيل فهي المدخل الأساسي لزيادة الإنتاجية، وتعتمد فاعلية وتأثير المدخلات الأخرى مثل الري والأسمدة وغيرها على استخدام التقاوي المحسنة ذات الجودة العالية.
- يجب الحرص على الحصول على التقاوي المحسنة للأصناف المجازة من المصادر الموثوق بها.
- عمليات إعداد التقاوي تؤدي إلى التخلص من البذور الضامرة والمكسورة وبذور الحشائش الضارة والشوائب الأخرى بالإضافة إلى تعفير البذور.
- يوصى بتعفير التقاوي بمبيدات الحشرات والفطريات بالمعدلات الموصى بها وذلك حتى تتم وقاية المحصول من مخاطر الحشرات والأمراض الفطرية التي قد تصيبها عند الإنبات ومراحل النمو الأولى.



التوزيع الجيد والمتساوي للبذور في كل مساحة الحقل ضمان للتأسيس الجيد...

## 5. معدل التقاوي:

- يوصى باستخدام 50-60 كجم تقاوي للفدان تحت ظرف التحضير الجيد والتحكم في الريّة الأولى.
- في حالة القمح القاسي (الديورم) يوصى بإستخدام معدل تقاوي يتراوح بين 53 - 70 كيلوجرام للفدان في أراضي الكرو في نهر النيل.
- التحضير غير الجيد للأرض وعدم التحكم في الريّة الأولى وعدم الحرص على الزراعة بالآلة المناسبة وفي العمق المناسب من أهم الأسباب التي تؤدي الى تدني نسبة الإنبات وبالتالي التأسيس غير الجيد للمحصول الشيء الذي يضطر عدد من المزارعين لزيادة معدل التقاوي لتعويض هذا الخلل الذي يمكن تلافيه.
- في حالة التحضير الجيد تعطي هذه الكمية من التقاوي ما لا يقل عن 300-350 نبات في المتر المربع وهي الكثافة النباتية المطلوبة لتحقيق إنتاجيات عالية.
- أوضحت الدراسات أن القمح لديه القدرة على التعويض عند إستخدام معدلات تقاوي منخفضة من خلال طرح عدد من الخلف (الاشطاء) شريطة الإدارة الجيدة للمحصول من تحضير للأرض والتحكم في الري والتسميد المناسب ومكافحة الحشائش وغيرها.



إنتاج التقاوي عملية فنية تحتاج إلى المعرفة والمتابعة والدقة والاحلاص والأمانة...

## 6. إنتاج التقاوي:

- إنتاج التقاوي يحتاج إلى مراعاة عدد من الجوانب الفنية والتقيد بالشروط الفنية الصادرة من إدارة التقاوي ومنها:
- التأكد من مصدر التقاوي والحرص على الحصول على الشهادة للرتبة السابقة.
- التقيد بمسافات العزل المحددة لكل محصول والتأكد من أن المحصول السابق في الأرض المراد زراعتها لم يكن نجيباً مثل القمح والذرة.
- يجب التأكد من نظافة الزراعة عند الزراعة وكذلك الحاصدة عند الحصاد منعاً للخط الميكانيكي.
- لتيسير عملية التنقية وإزالة الشوائب يفضل تقليل معدل التقاوي عن المعدلات الموصى بها في الزراعة العادية.
- عمل التنقية اليدوية للسنايل الغربية عن الصنف المقصود إكثاره وإقتلاعها مع كل خلفها.



الطريقة المثلى للزراعة هي التي تضمن وضع البذور في عمق مناسب والتوزيع الجيد للبذور في الرقعة المراد زراعتها ...

## 7. طرق الزراعة:

- الطريقة المثلى لزراعة القمح ينتج عنها وضع البذور داخل التربة بعمق 5-7.5 سم وإلى توزيع البذور بالتساوي في الرقعة الزراعية المستهدفة.
- يستحسن أن تكون الزراعة بالزراعة (السطارة) على سطور تتباعد عن بعضها البعض بمسافة 20 سم.
- في حالة عدم توفر السطارة يمكن إستعمال الدسك العريض شريطة مراعاة عمق الزراعة أو النثر ثم التسريب.
- لتحقيق تأسيس جيد يمكن القيام بالزراعة بعد التروية، الزراعة على اللبان، الزراعة والتسريب الخفيف بالبنجة على بعد 40 سم أو الزراعة على السطح في تربة ناشفة شريطة مراعاة التسوية الجيدة.
- الزراعة على المساطب 80 سم بالآلة (3 صفوف) تسهل عملية الري وتمنع الغرق وتساعد في تقليل معدل التقاوي.
- في كل الحالات يجب الحرص على تقسيم الحقل (الحواشة) إلى جداول وتقانت لتسهيل عملية الري.
- في حالة عدم التحضير الجيد للأرض يفضل زيادة عدد الرباطات أو التسريب الخفيف للتحكم في علمية الري.



الزراعة مواقيت والالتزام بالمواقيت الموصى بها يجنبك الكثير من مخاطر فقدان الانتاجية ...

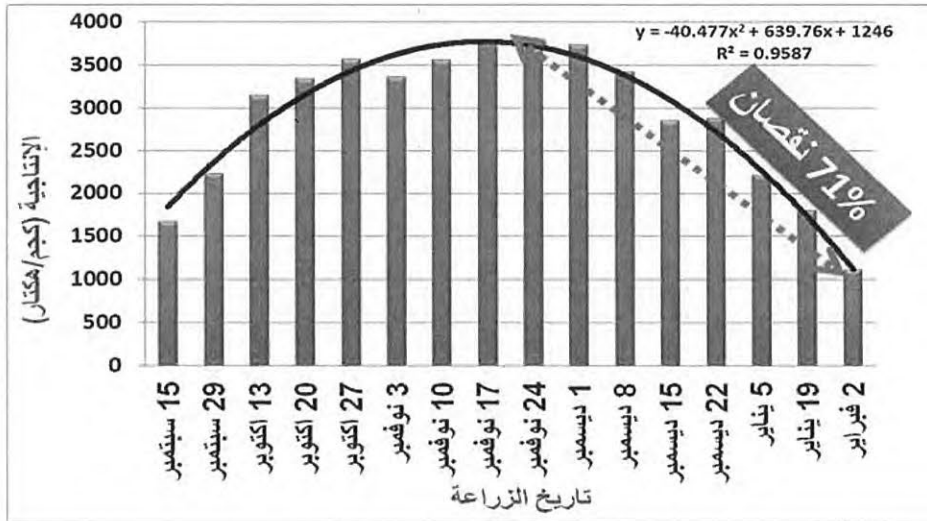
## 8. مواقيت الزراعة:

- أنسب تاريخ لزراعة القمح في السودان هو الذي يجعل فترات النمو الحرجة للنبات (تكوين السنابل، الإزهار، وتكوين وإمتلاء الحبوب) تتزامن مع أكثر الفترات برودةً أثناء الموسم (ديسمبر - يناير - فبراير).
- إرتفاع درجات الحرارة في فترة النمو الخضري يؤدي إلى سرعة الإزهار وتكوين سنابل صغيرة وقليلة العدد كما أن إرتفاعها أثناء الإزهار يؤدي إلى ضعف الإخصاب وعدد قليل من الحبوب وإرتفاعها أثناء تكوين الحبوب ينتج عنه حبوب ضامرة.
- تختلف درجة تحمّل الإجهاد الحراري في بداية الموسم من صنف إلى آخر. عموماً الأصناف متأخرة النضج أكثر تحملاً للحرارة في بداية الموسم مقارنة بالأصناف مبكرة النضج. لذا لا ينصح بزراعة الأصناف المبكرة قبل النصف الأول من شهر نوفمبر.
- المدى الزمني الأمثل لتاريخ زراعة القمح في السودان يمتد بين 3 نوفمبر إلى 12 ديسمبر ولكنه يختلف بإختلاف مناطق زراعة القمح وبإختلاف الأصناف. ففي وسط السودان تعتبر الزراعة خلال شهر نوفمبر هي الأمثل بينما تمتد الفترة في الولايات الشمالية حتى الثلث الأول من ديسمبر.
- يفضل زراعة القمح خلال الأسبوع الثاني والثالث من نوفمبر للأصناف المتأخرة النضج في وسط السودان.



## تأخير الزراعة قد يؤدي إلى تقليل الانتاجية بصورة كبيرة ...

- ويمكن الإستمرار في الزراعة حتى الأسبوع الأخير من نوفمبر بالنسبة للأصناف المتوسطة النضج.
- أما الأصناف المبكرة النضج فيمكن زراعتها في الفترة من الأسبوع الأخير من نوفمبر وحتى الأسبوع الأول من ديسمبر.
- أي تأخير عن المواعيد المذكورة أعلاه يؤدي لتقليل الإنتاجية بصورة مطردة، فمثلاً تأخير الزراعة إلى يوم 20 ديسمبر أدى إلى 55% فقدان في الإنتاجية وإلى أكثر من 71% عند تأخيرها إلى بداية فبراير بدلاً عن 20 نوفمبر (الشكل 2).



الشكل (2): أثر تاريخ الزراعة على إنتاجية القمح في ولاية نهر النيل  
المصدر: ابراهيم 1996

لضمان الاستفادة القصوى من التسميد لابد من إختيار السماد المناسب والتوقيت المناسب والتوزيع الجيد المتساوي في كل الرقعة المزروعة ...

## 9. التسميد:

تختلف حاجة القمح للتسميد باختلاف أنواع الترب ولكن معظمها تحتوي على نسب ضئيلة من عنصري الأزوت (النيتروجين) والفسفور وهما من العناصر الرئيسية التي لا يمكن تحقيق إنتاجيات عالية واقتصادية دون إستخدامهما.

- هنالك العديد من مصادر الفسفور والنيتروجين ويعتمد الإختيار من بينها على عدة عوامل منها توفرها في الاسواق وأسعارها وطريقة وتوقيت وملاءمة إستخدامها وغيرها.
- التسميد بالفسفور:

- ◆ عند التوزيع الجيد والمتساوي للسماد، يحتاج القمح إلى 18 كجم أكسيد الفسفور/ الفدان {40 كجم من الفسفور الثلاثي السيوبر، (TSP) أو الداب (DAP) أو 32.5 كجم من فوسفات الأمونيوم الأحادي (الماب، MAP)}.
- ◆ يوضع السماد الفسفوري داخل التربة مع الزراعة عند إستعمال الزراعة أو قبل الدسك أو ينثر قبل الزراعة ويتم دفنه مع البذرة أثناء عملية الزراعة حرصاً على وضعه قريباً من البذور وذلك نسبة لبطء حركته وإمكانية تثبيته في التربة بسبب قلوبتها العالية.
- ◆ عدم الإلتزام بوضع السماد الفسفوري في الموضع المناسب وتوزيعه الجيد في الحقل قد يقود إلى عدم الإستفادة المثلى منه وبالتالي اللجوء لزيادة الجرعة لتوفير الإحتياج الحقيقي للمحصول.
- ◆ إضافة سماد الفسفور تزيد الإنتاجية بـ 25-50% في الأراضي التي لديها الإستجابة للفسفور.
- ◆ ليست هنالك إستجابة للتسميد بالفسفور في أراضي الجروف والجزر شمال الخرطوم، كما أن هنالك نتائج متباينة لأثر السماد الفسفوري على إنتاجية القمح في حلفا الجديدة وتحتاج إلى تأكيدها بإجراء بحوث مكثفة.

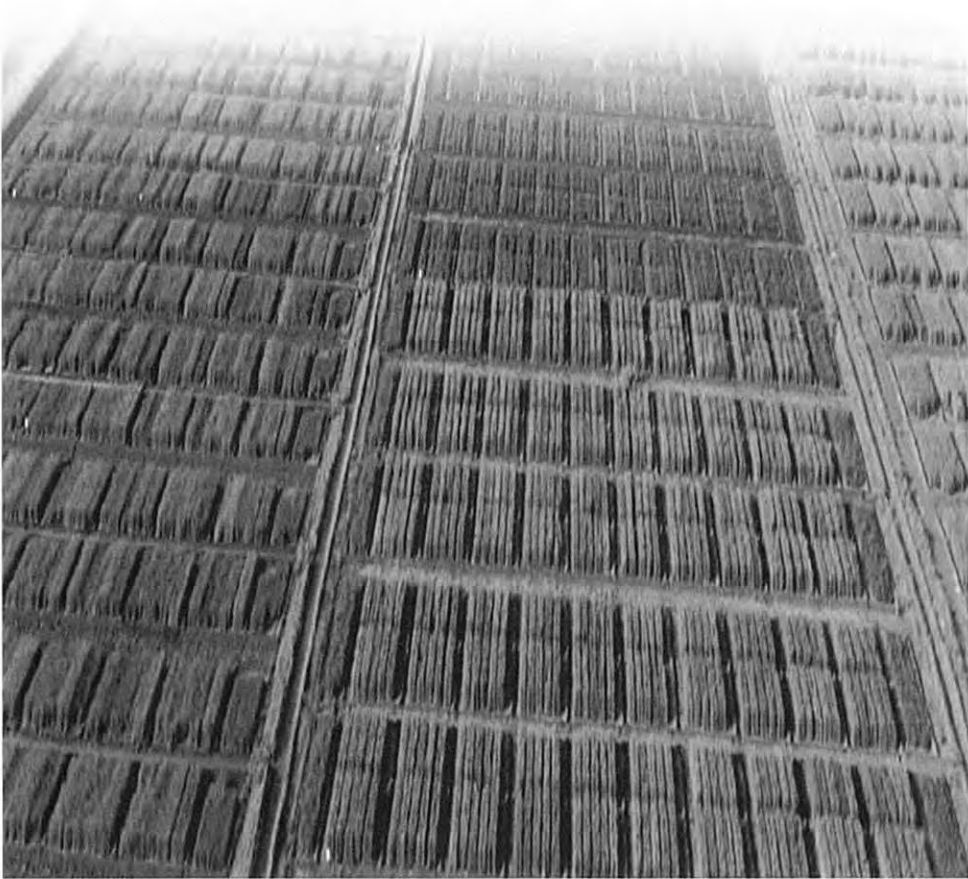
تجنب تعريض سماد اليوريا لأشعة الشمس والرطوبة لتفادي فقدانه عن طريق التبخر ...

• التسميد بالنيتروجين:

- ◆ يسمد القمح بالأسمدة الأزوتية (النيتروجينية) بحوالي 36 كجم / الفدان من عنصر النيتروجين (80 كجم / الفدان من اليوريا).
- ◆ في حالة التأسيس الجيد للمحصول والقيام بكل العمليات الفلاحية بصورة جيدة يمكن زيادة جرعة النيتروجين الى حوالي 120 كجم يوريا للفدان.
- ◆ في حالة القمح القاسي (الديورم) تمت التوصية بمعدل تسميد باليوريا يتراوح بين 100-140 كجم يوريا للفدان (46-63 كجم نيتروجين للفدان) في أراضي الكرو في نهر النيل.
- ◆ في حالة استخدام الداب أو الماب كمصدر للفسفور، يفضل أن تقسم جرعة اليوريا إلى قسمين حيث تضاف الجرعة الأولى مع الريّة الثانية (بداية الخلف) وتضاف الجرعة الثانية مع الريّة الرابعة (مرحلة إستطالة الساق أو الحملة).
- ◆ عدم إضافة النيتروجين قد يقلل الإنتاجية بـ 35-65% اعتماداً على نوعية التربة والمحصول السابق وغيرها.
- ◆ إضافة السماد الأزوتي بعد الإزهار لا تؤدي الى زيادة في الإنتاجية لكنها قد تحسّن من نوعية الحبوب (زيادة البروتين).
- ◆ لتقليل الفاقد من سماد اليوريا يجب الحرص على تطبيقه في نفس يوم الري وعدم تركه ليتعرض لأشعة الشمس والرطوبة لأن ذلك يؤدي إلى فقدانه عن طريق التبخر.
- ◆ يجب الحرص على التوزيع الجيد للسماد وأن تكون الريّة التي يطبق فيها السماد رية خفيفة، كما يجب تلافي الغرق والحرص على عدم تسرب مياه الري خارج الحقل.

إضافة الأسمدة العضوية تحسّن الخواص الفيزيائية والكيميائية للتربة خاصة الفقيرة منها مثل أراضي التروس العليا ...

- ويوصى بإضافة الأسمدة العضوية خاصة لأراضي التروس العليا في حدود 2-5 طن للفدان.
- بعض الأسمدة الورقية أعطت نتائج إيجابية لإنتاجية القمح عند إستخدامها مع الجرعة الموصى بها من النيتروجين والفسفور وتحت ظروف الإدارة الجيدة للمحصول رغم أن هذه النتائج غير ثابتة في كل المواقع ولذا لم تتم التوصية بها.



القمح حساس للعطش والغرق والمتابعة اللصيقة تضمن سلامة المحصول...  
يجب الاهتمام الشديد بالري خاصة الريّة الأولى...

## 10. الري:

- ترب السهل الطيني الأوسط طينية ثقيلة ذات نفاذية ضعيفة للمياه ولذلك تتعرض للغرق بسهولة.
- القمح لديه حساسية شديدة للمياه الزائدة (الغرق) أثناء الإنبات، عليه يجب الإهتمام الشديد بالري خاصة الريّة الأولى والثانية. وللمساعدة على ذلك يجب تقسيم الحواشة بعد زراعتها إلى أحواض أو رباطات، يتم ريها بحرص شديد بحيث لا تكون هنالك أي مياه راكدة على السطح بنهاية يوم الري.
- ويوصى أن تكون الريّة الأولى خفيفة لتحقيق التأسيس الجيد والإسراع بالريّة الثانية في خلال 10-12 يوم من الريّة الأولى.
- إنتاجية القمح تتوقف على التأسيس الجيد للمحصول وأي خلل في التأسيس (وجود فراغات) يؤدي إلى إنتاجيات ضعيفة بسبب قلة عدد السنابل في وحدة المساحة المعينة. التأسيس الجيد يساعد على تقليل منافسة الحشائش للمحصول لأن وجود مساحات فارغة تشجع على نمو الحشائش والتي تنافس المحصول وتزيد من تكلفة الإنتاج بالحدس اليدوي أو المكافحة الكيميائية.
- فترات الري تعتمد اعتماداً كبيراً على مراحل نمو المحصول، نوعية التربة وعلى درجات الحرارة السائدة أثناء الموسم. لذا يجب أن يتابع المزارع حقله بشكل شبه يومي لمعرفة الحاجة الفعلية للري دون التقييد بالفترات المذكورة أعلاه.



المكافحة المتكاملة للآفات تقود إلى مكافحة فاعلة وآمنة لآفات الحشائش والحشرات والأمراض مع المحافظة على سلامة البيئة...

## 11. وقاية المحصول:

المكافحة المتكاملة للآفات:

- يجب إتباع نظام المكافحة المتكاملة للآفات عند التعامل مع كل الآفات التي تصيب محصول القمح والمحاصيل الأخرى.
- المكافحة المتكاملة للآفات هي عبارة عن نظام متكامل لإدارة الآفات يستخدم فيه كل طرق المكافحة المختلفة مثل الطرق الفلاحية، الحيوية، الميكانيكية، الكيماوية، التشريعية وغيرها في نظام مثالي يهدف إلى خفض أضرار الآفات والسيطرة عليها وبقائها دون الحد الإقتصادي الحرج للمعاملة أو التدخل الكيميائي مع المحافظة على سلامة البيئة.
- على سبيل المثال، استخدام الطرق الفلاحية بإتباع الدورة الزراعية المناسبة والتحضير الجيد للأرض في الوقت المناسب وتعفير البذور وإستخدام الصنف المقاوم للأصداء يمكنها أن تؤدي إلى مكافحة فاعلة وآمنة للحشائش والحشرات والأمراض في محصول القمح.



التحضير الجيد للأرض والتأسيس الجيد للمحصول واتباع الدورة الزراعية المناسبة تقلل كثيراً من نمو الحشائش ...

أهم آفات القمح تتمثل في:

### 1.11 الحشائش:

- إذا تم تأسيس محصول القمح تأسيساً جيداً فإن ذلك يقلل من ظهور الحشائش بصورة ملحوظة.
- قد تنمو بعض الحشائش التي يمكن إزالتها بالرش بسهولة خلال 3-4 أسابيع من الإنبات (الشهر الأول من عمر المحصول) حيث أن تأخير الرش يؤدي إلى زيادة في حجم الحشائش وبالتالي صعوبة مكافحتها. يمكن استخدام المبيدات الحشائشية المجازة حسب الجرعة الموصى بها مثل:
  - ◆ مركبات الـ D-4-2 لمكافحة الحشائش ذات الأوراق العريضة ويوجد العديد منها، تختلف جرعة المبيد حسب التركيز وتتراوح بين 1000 سي سي (ملييلتر) للفدان للمبيدات التي تركيزها 60% و830 سي سي للفدان للمبيدات ذات التركيز 72%. يجب تطبيق عملية رش المبيدات في المواعيد الموصى بها خاصة مبيدات الـ D-4-2 لأن تأخير الرش قد يؤدي لتشوهات في السنابل.
  - ◆ مبيدات مكافحة العذار والشوفان والحشائش النجيلية الأخرى مثل البوما أو التوبيك أو التراكسوس والتيردوك والتوب نور وغيرها. الجرعة لأغلب هذه المبيدات هي 420 سي سي للفدان.



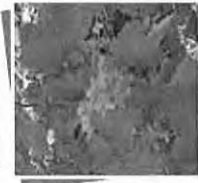
فجيلة



عذار



تبر



رامتوك

اختيار المبيد المناسب والبشور الصحيح والرش في الفترات الصباحية أو المسائية تزيد كثيراً من فاعلية مبيدات الحشائش...

- يجب استخدام البشور (الفونية) الصحيح لضمان التغطية الكاملة للحشائش بالمبيد وذلك لضمان فاعليته.
- لضمان فاعلية المبيد يجب تجنب الرش في حالة عطش المحصول وكذلك يجب تجنب الرش في حالات الرياح الشديدة.
- يوصى بالرش في الفترات الصباحية أو المسائية وتجنب الرش في فترة الظهيرة حتى يتم إمتصاص المبيد من قبل الحشائش المستهدفة. كما يوصى بعدم الري مباشرة بعد الرش ويستحسن ترك المبيد لمدة لا تقل عن 6-12 ساعة لكي تكتمل عملية الإمتصاص.
- عند تواجد الحشائش عريضة الأوراق والنجيلية مثل العدار فيمكن المكافحة بخلط مبيدات معينة مع بعضها مثل خلط التوبيك مع الديالين سيوبر بجرعة 420 سي سي من التوبيك و380 سي سي من الديالين سيوبر للفدان. وكذلك يمكن خلط التوبيك مع الجنتان بجرعة 420 س س من التوبيك و3 جرام من الجنتان للفدان الواحد.
- هنالك بعض المبيدات ذات أثر مزدوج للحشائش عريضة الأوراق والنجيلية تمت التوصية بها حديثاً مثل أتلانتس (Atlantis) بجرعة 525 سي سي للفدان.

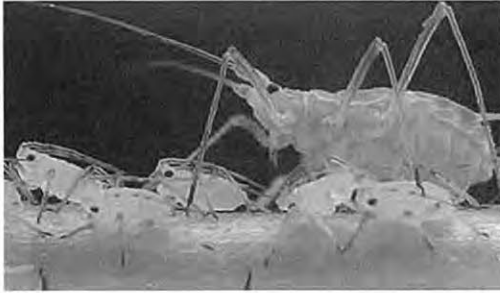


شكل البشابير المستخدمة لتطبيق مبيدات الحشائش

التعفير الجيد للتقاوي بالمبيدات الموصى بها يقلل كثيراً من مخاطر الإصابة بالآفات خاصة في مراحل النمو الأولى...

## 2.11. الحشرات:

- يصاب القمح بعدد من الحشرات والآفات أهمها حشرة المن، ثاقبات الساق، حافرات الأنفاق، النمل الأبيض (الأرضة) بالإضافة إلى بعض الآفات القومية مثل الفأر والطيور والجراد.
- حشرة المن تعتبر من أهم الحشرات التي تؤثر تأثيراً إقتصادياً على محصول القمح. وتقل الإصابة عند تعفير التقاوي بالمبيدات الموصى بها بصورة كبيرة، وإذا حدثت الإصابة ووصلت للحد الإقتصادي الحرج للرش (35% من النباتات مصابة) فيمكن معالجتها بالرش بمبيدات مجازة وفعالة.
- يوصى بتعفير التقاوي بمبيدات الحشرات والفطريات بالمعدلات الموصى بها.
- مبيدات الحشرات الموصى بها تشمل مجموعة الإמידاكلوبريد (Imidacloprid) مثل القاوشو والقوليش (تستخدم بمعدل 0.5 جم (س س) من القاوشو لكل كيلوجرام من التقاوي). أما مبيدات الفطريات فتشمل مجموعة التيوبوكونازول (Tubconazol) مثل الراكسيل (تستخدم بمعدل 1.5 جم من الراكسيل لكل كيلو من التقاوي).
- هنالك بعض معفرات البذور تحتوي على المبيدات الحشرية والفطرية معاً مثل السيليستوب (Celest Top) وغيرها.



تأكد من الحصول على المبيدات المناسبة من مصادرها الموثوقة...

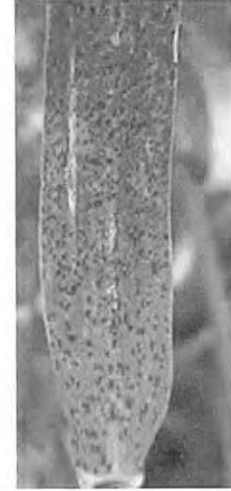
- معظم معفرات البذور تعطي حماية للمحصول من آفات العسلة والأرضة لفترة تتراوح بين 45-60 يوم مما يقلل من تطبيق المبيدات السائلة بالرش الجوي.
- في حالة معاملة البذور بالمعفرات يجب الحرص على الحصول عليها من المصادر الموثوق بها والإلتزام بإتباع إجراءات السلامة عند التعفير.
- هنالك بعض الأعداء الطبيعية مثل أبو العيد تساعد كثيراً في القضاء أو التقليل من الإصابة بحشرة المن.
- أيضاً يتأثر القمح ببعض الآفات الثانوية مثل ثاقبات الساق ولكن حتى الآن لا تعتبر من الآفات الاقتصادية.
- أما الآفات القومية فتتم إدارتها والسيطرة عليها من قبل الإدارة العامة لوقاية النباتات المركزية أو الولائية.



اختيار الصنف المقاوم لأمراض الصدأ هو أنسب وسيلة لتجنب الإصابة بها في منطقة حلفا الجديدة ...

### 3.11. الأمراض:

- أمراض الصدأ (صدأ الساق الأسود وصدأ الأوراق) هي من أهم الأمراض التي تؤثر إقتصادياً على محصول القمح.
- يتركز إنتشار هذه الأمراض في منطقة حلفا الجديدة نسبة لملائمة المناخ (الرطوبة العالية ودرجات الحرارة).
- زراعة الأصناف المقاومة لهذه الأمراض هي الوسيلة الأمثل لتلافي آثارها السالبة وقد تصل نسبة فقدان المحصول إلى 70% عند زراعة الأصناف الحساسة لهذه الأمراض.
- هنالك عدد من الأصناف المقاومة لهذه الأمراض تمت إجازتها مثل أمل، الشيبك، جواهر، صلاح وخديوي.
- تمت إجازة المبيد الفطري برايوري أكسترا (Priori Xtra 280 SC) لمكافحة أمراض الصدأ بمعدل 200 سي سي للفدان ترش على مرتين: عند ظهور المرض وبعد أسبوعين لاحقاً.



التأخير في الحصاد وعدم التأكد من سلامة الحاصدة وكفاءتها قد تؤدي إلى فقدان كبير في إنتاجية المحصول ...

## 12. الحصاد وعمليات ما بعد الحصاد:

- يكون القمح جاهزاً للحصاد عندما تجف النباتات ويكون من السهل كسر الساق وفصل البذور عن السنابل.
- التأخير لأكثر من 4 أسابيع من هذا التاريخ يؤدي لفقد كبير في الإنتاجية قد يصل إلى 30% من الانتاج نتيجة تفرط البذور.
- يجب الحرص على أن تكون الريبة الأخيرة خفيفة لتفادي رقاد المحصول ونمو الحشائش التي قد تعيق عملية الحصاد الآلي.
- يجب الحرص على كسر التقانات والجداول قبل بدء عملية الحصاد وذلك لتقليل الفاقد والحرص على سلامة الحاصدات.
- يجب التأكد من سلامة الحاصدة وكفاءتها وضبطها قبل البدء في عملية الحصاد.
- من الضروري جداً التحكم في سرعة الحاصدة أثناء الحصاد لأن السرعة الزائدة تؤدي إلى فقدان نسبة مقدره من المحصول.
- في حالة تخزين المحصول أو التقاوي، يجب التأكد من التخزين الجيد في مخازن ذات تهوية جيدة ومراعاة درجات الحرارة والرطوبة المناسبة للتخزين.
- يراعى إستخدام المبيدات الموصى بها وبالطرق الصحيحة عند المكافحة الكيميائية لآفات المخازن مع مراعاة فترة الأمان للمبيدات المستخدمة.



باختيار الصنف المناسب والادارة الجيدة للمحصول خاصة التسميد يمكن الحصول على نوعية جيدة للحبوب ...

### 13. نوعية الحبوب (الجودة)

- أهم ما يميز حبوب القمح عن المحاصيل الأخرى هو إحتوائها على مادة البروتين والقلوتين والتي تكسب العجين صفتي اللزوجة والمرونة.
- من أهم العناصر التي تحدد جودة حبوب القمح هي درجة صلابة وكثافة الحبوب، نسبة إستخلاص الدقيق، كمية ونوعية البروتين ونسبة ونوعية القلوتين. رغم أن كل هذه الصفات تحدد وراثياً في الصنف المعين لكنها تتأثر بدرجات متفاوتة بالعوامل البيئية والعمليات الفلاحية المختلفة.
- التسميد ودرجات الحرارة هما من أكثر العوامل تأثيراً على نوعية الحبوب.
- درجات الحرارة العالية في نهاية الموسم تؤدي غالباً إلى زيادة كمية البروتين في الدقيق لكنها في المقابل تؤدي إلى نقصان قوة ومقاومة العجين للخلط.
- بعض الأصناف السودانية تحمل في تراكيبها الجينية وحدات جزيئية مرغوبة من البروتين والقلوتين والتي تحدد إلى درجة كبيرة جودة دقيق القمح وإستعمالاته. مثال لذلك إمام، ساساريب، زكية وعجيب.
- لوحظ أن هنالك تدنى في نسبة البروتين والقلوتين الرطب عند إختبار عينات قمح أخذت من حقول مزارعين مقارنة مع عينات أخذت من محطة بحوث الجزيرة. يرجع ذلك غالباً لعدة عوامل أبرزها عدم إستعمال تقاوي نقيه من الصنف المعين وعدم الالتزام بالعمليات الفلاحية وخاصة التسميد بالازوت ونظافة الحشائش.



تختلف جودة أصناف القمح باختلاف الاستخدام النهائي للحبوب ...

- زراعة الصنف المناسب في التاريخ المناسب مع التطبيق الجيد للتقانات ستؤدي إلى إنتاج نوعية جيدة من حبوب القمح من أصناف مثل دبيرة، ساسريب، إمام، ركية وعجيب، الخ.
- تختلف الجودة المطلوبة في القمح باختلاف الاستخدام النهائي فمثلاً هنالك أصناف تصلح لصناعة الخبز بينما أخرى يفضل استخدامها دقيقها لعمل البسكويت والخبائز والقراصة وغيرها.
- إضافة السماد الأزوتي والكبريت بعد الإزهار تحسّن نوعية القمح ولكنها قد لا تؤدي لزيادة في الإنتاجية.



الإدارة المتكاملة للحقل والاهتمام بتطبيق الخيارات التقنية تؤدي إلى تحقيق عائد مجزي من محصول القمح ...

#### 14. إقتصاديات إنتاج القمح:

نسبة للتفاوت الكبير في قيمة الجنيه السوداني فقد تم حساب تكلفة زراعة القمح بالعائد من المنتج (كجم قمح)، هذه الطريقة ربما تساعد في تحديد أسعار القمح مستقبلاً بالأخذ في الإعتبار تكلفة الإنتاج والعائد من المنتج.

• التكلفة الكلية لفدان القمح في المشاريع المروية تتراوح غالباً بين العائد من 5-7 جوال (0.5-0.7 طن) من المنتج اعتماداً على أسعار المدخلات والقمح. يعني ذلك أن الأرباح من إنتاج 12-14 جوال (1.2-1.4 طن للفدان) تعادل أكثر من 100% من التكلفة. وإذا أخذنا في الإعتبار أن عدداً مقدراً من المزارعين ينتجون أكثر من 16 جوال للفدان (1.6 طن للفدان) فإن العائد من القمح لدى هؤلاء المزارعين هو حوالي 150% من التكلفة في خلال 4-5 شهور.



نسبة العائد الى التكاليف: كلما زادت الانتاجية الرأسية زادت نسبة العائد من القمح وقد تصل إلى أكثر من 200 % من التكاليف ...

التكلفة الكلية لزراعة فدان القمح والإنتاجية والعائد المتوقع حسب تكلفة مدخلات الإنتاج والسعر التركيبي للقمح في موسم 2019 / 2020

تكلفة الفدان (كجم قمح)			
البيان	الشمالية ونهر النيل	الجزيرة وحلفا الجديدة	النيل الأبيض
التحضير (الأول والثاني)	40	35	40
الزراعة بالآلة	10	10	7
التقاوي 60 كجم / فدان	80	80	80
السماذ	140	140	140
مبيد الحشائش (العريضة والنجيلية)	35	35	35
نثر السماذ ورش المبيدات	10	10	10
الإشراف الإداري والفني	10	8	8
الحصاد الآلي	40	35	35
الخيض	55	50	50
خدمات الإدارة ومياه الري	45	40	40
الزكاة	65	60	60
التأمين الزراعي	10	10	10
تكلفة الري (8 ريات)	60	50	60
الجهد العام للمزارع	30	30	30
جملة التكلفة (كجم للفدان)	630	593	605
جملة التكلفة (بالجنيه حسب أسعار 2020)	22050	20755	21175
متوسط إنتاجية الفدان (كجم)	1300	1200	1200
جملة العائد (بالجنيه حسب أسعار 2020)	45500	42000	42000
صافي الإنتاج للفدان الواحد (كجم)	670	607	595
صافي الأرباح للفدان (بالجنيه حسب أسعار 2020)	23450	21245	20825
نسبة العائد إلى التكاليف	2.06	2.03	1.98

التحسين الوراثي، الكفاءة الانتاجية، تخفيض تكلفة الانتاج والاهتمام المتكامل بسلسلة قيمة القمح هي الضمان لإستدامة زراعة القمح في السودان...

## مستقبل زراعة القمح في السودان

• على الرغم من الزيادة المضطردة في إنتاج وإنتاجية القمح في السودان مؤخراً فإن إستهلاك القمح يزداد بوتيرة أكبر مما زاد من إستيراده لسد الفجوة.  
• ولأن إستيراد القمح يفرض عبئاً كبيراً على الاقتصاد السوداني فإن سد الفجوة بين الإنتاج والاستهلاك يتطلب زيادة الإنتاج المحلي من خلال زيادة الإنتاجية لكل وحدة مساحة إلى جانب التوسع الأفقي، ولتحقيق ذلك يجب أن تتضمن الخطة المستقبلية الآتي:

- تحسين القمح من خلال تطبيق التقنيات التقليدية والحديثة لملائمة التغيرات المناخية وتطوير أصناف مقاومة للحرارة ونقص المياه وذات كفاءة عالية في استخدام المغذيات وتحسين القيمة الغذائية وجودة الاستخدام النهائي للقمح.
- إستغلال وإكمال الطاقة الإنتاجية الحالية في المشاريع الزراعية القائمة وإعادة تأهيلها لزيادة كفاءتها.
- توسيع مناطق إنتاج القمح، وخاصة في الامتدادات الجديدة للمشاريع القائمة والتوسع الأفقي في مناطق إنتاج جديدة والاستخدام الأمثل للموارد الطبيعية بما في ذلك مخزون المياه الجوفية
- تخفيض تكلفة الإنتاج وزيادة القدرة التنافسية لمحصول القمح.
- الإهتمام بسلسلة القيمة وتقوية نقاط الضعف فيها (عمليات ما بعد الحصاد، الجودة، التخزين، وغيرها) وتكوين المجالس السلعية (مجلس سلعة القمح).

• وفي ظل التغيرات المناخية وما يصاحبها من آثار ضارة متوقعة لإنتاج القمح مثل إرتفاع درجات الحرارة، لا بد من دراسات تحليلية شاملة تساعد في تطوير وتوفير سيناريوهات ونماذج بديلة لإنتاج القمح في السودان تلائم هذه التغيرات المتوقعة وكذلك تطوير وإستنباط تقانات إنتاج قمح صديقة للبيئة وتلائم التغيرات المناخية.

• تعمل هيئة البحوث الزراعية في السودان بالتعاون مع بعض المؤسسات الوطنية والمنظمات البحثية والجامعات العالمية في وضع سيناريوهات لإنتاج القمح في السودان مستقبلاً تلائم التغيرات المناخية المتوقعة.

## مشروع تقانات مبتكرة لإنتاج مستدام للقمح (تمام)



### أهداف المشروع:

زيادة إنتاج القمح وإنتاجيته في السودان لتحقيق الاعتماد على الذات من خلال تسريع عملية تحسين القمح لملائمة التغيرات المناخية، وضع سيناريوهات ونماذج بديلة لإنتاج القمح لتلائم التغيرات المناخية، تطوير وتنفيذ خطط إنتاج التقاوي، نشر التقانات والابتكارات باتباع منهجية منصات الابتكار والمنصات الرقمية وبناء القدرات لجميع أصحاب المصلحة على طول سلسلة قيمة القمح.

### الجهات المنفذة:

هيئة البحوث الزراعية بالتعاون مع الهيئة العامة للأرصاد الجوية السودانية وجامعة توتوري بالتعاون مع جامعة تسوناميا في اليابان.

### الجهات الممولة:

الوكالة اليابانية للعلوم والتكنولوجيا، الوكالة اليابانية للتعاون الدولي وحكومة السودان (المكون المحلي).

هيئة البحوث الزراعية - برنامج بحوث القمح - الطبعة الثانية ديسمبر 2023

## للاستفسار



**Annex 2-1.1. List of publications (Paper, book, movie)**

(A). Original articles co-authored with the research team of the partner country

Fiscal Year	Paper information	DOI Code	Domestic/International	Status
2020	Elhadi G. M. I., Kamal N. M., Gorafi Y. S. A., Yamasaki Y., Takata K., Tahir I. S. A., Itam M. O., Tanaka H. and Tsujimoto H., "Exploitation of tolerance of wheat kernel weight and shape-related traits from <i>Aegilops tauschii</i> under heat and combined heat-drought stresses. ", International Journal of Molecular Sciences, 2021. 02, 22, pp. 1830	<a href="https://doi.org/10.3390/ijms22041830">https://doi.org/10.3390/ijms22041830</a>	International	Published
2020	Iizumi T., Ali-Babiker I. E. A., Tsubo M., Tahir I. S. A., Kurosaki Y., Kim W., Gorafi Y. S. A., Idris A. A. M. and Tsujimoto H., "Rising temperatures and increasing demand challenge wheat supply in Sudan. ", Nature Food, 2021. 01, 2, pp. 19-27	<a href="https://doi.org/10.1038/s43016-020-00214-4">https://doi.org/10.1038/s43016-020-00214-4</a>	International	Published
2020	Mahjoob M. M. M., Gorafi Y. S. A., Kamal N. M., Yamasaki Y., Tahir I. S. A., Matsuoka Y. and Tsujimoto H., "Genome-wide association study of morpho-physiological traits in <i>Aegilops tauschii</i> to broaden wheat genetic diversity. ", Plants, 2021. 01, 10, pp. 211	<a href="https://doi.org/10.3390/plants10020211">https://doi.org/10.3390/plants10020211</a>	International	Published
2021	Tanaka, H, Gorafi Y. S. A., Fujita M., Sasaki H., Tahir I. S. A. and Tsujimoto H., " Expression of seed storage proteins responsible for maintaining kernel traits and wheat flour quality in common wheat under heat stress conditions. ", Breeding Science, 2021. 05, 71, pp. 184-192	<a href="https://doi.org/10.1270/jsbbs.20080">https://doi.org/10.1270/jsbbs.20080</a>	International	Published
2021	Mahjoob M. M. M., Chen T., Gorafi Y. S. A., Yamasaki Y., Kamal N. M., Abdelrahman M., Iwata H., Matsuoka Y., Tahir I. S. A. and Tsujimoto H., "Traits to differentiate lineages and subspecies of <i>Aegilops tauschii</i> , the D genome progenitor species of bread wheat. ", Diversity, 2021. 05, 13, pp. 217	<a href="https://doi.org/10.3390/d13050217">https://doi.org/10.3390/d13050217</a>	International	Published
2021	Elhadi G. M. I., Kamal N. M., Gorafi Y. S. A., Yamasaki Y., Ban Y., Kato K., Tahir I. S. A., Ishii T., Tanaka H. and Tsujimoto H., "Novel loci for kernel hardness appeared as a response to heat and combined heat-drought conditions in wheat harboring <i>Aegilops tauschii</i> diversity. ", Agronomy, 2021. 05, 11, pp. 1061	<a href="https://doi.org/10.3390/agronomy11061061">https://doi.org/10.3390/agronomy11061061</a>	International	Published
2021	Musa A. I. I., Tsubo M., Imad-Eldin A. A. B., Iizumi T., Kurosaki Y., Ibaraki Y., El-Hag F., Tahir I. S. A. and Tsujimoto H., "Relationship of irrigated wheat yield with temperature in hot environments of Sudan. ", Theoretical and Applied Climatology, 2021. 06, 145, 3-4, pp. 1113-1125	<a href="https://doi.org/10.1007/s00704-021-03690-1">https://doi.org/10.1007/s00704-021-03690-1</a>	International	Published
2021	David E., Serouart M., Smith D., Made S., Velumani K., Liu S., Wang X., Pinto F., Shafiee S., Tahir I. S. A., Tsujimoto H., Nasuda S., Zheng B., Kirchgessner N., Aasen H., Hund A., Sadhegi-Tehran P., Nagasawa K., Ishikawa G., Dandriofosse S., Carlier A., Dumont B., Mercatoris B., Evers B., Kuroki K., Wang H., Ishii M., Badhon M. A., Pozniak C., LeBauer D. S., Lillemo M., Badhon M. A., Poland J., Chapman S., de Solan B., Baret F., Stavmess I. and Guo W., "Global wheat head detection 2021: An improved dataset for benchmarking wheat head detection methods. ", Plant Phenomics, 2021. 09, 2021, pp. 9846158	<a href="https://doi.org/10.34133/2021/9846158">https://doi.org/10.34133/2021/9846158</a>	International	Published
2021	Itam M. O., Gorafi Y. S. A., Tahir I. S. A. and Tsujimoto H., "Genetic variation in drought resilience-related traits among wheat multiple synthetic derivative lines: insights for climate resilience breeding. ", Breeding Science, 2021. 08, 714, pp. 435-443	<a href="https://doi.org/10.1270/jsbbs.20162">https://doi.org/10.1270/jsbbs.20162</a>	International	Published
2021	Itam M. O., Mega R., Gorafi Y. S. A., Yamasaki Y., Tahir I. S. A., Akashi K. and Tsujimoto H., "Genomic analysis for heat and combined heat-drought resilience in bread wheat under field conditions. ", Theoretical and Applied Genetics, 2021. 10, 1351, pp. 337-350	<a href="https://doi.org/10.1007/s00122-021-03969-x">https://doi.org/10.1007/s00122-021-03969-x</a>	International	Published
2021	Osman S. O. M., Saad A. S. I., Tadano S., Takeda Y., Konaka T., Yamasaki Y., Tahir I. S. A., Tsujimoto H. and Akashi K., "Chemical fingerprinting of heat stress responses in the leaves of common wheat by fourier transform infrared spectroscopy. ", International Journal of Molecular Sciences, 2022. 03, 23, 5, pp. 2842	<a href="https://doi.org/10.3390/ijms23052842">https://doi.org/10.3390/ijms23052842</a>	International	Published
2021	Balla M. Y., Gorafi Y. S. A., Kamal N. M., Abdalla M. G. A., I. S. A. Tahir and Tsujimoto H., "Harnessing the diversity of wild emmer wheat for genetic improvement of durum wheat. ", Theoretical and Applied Genetics, 2022. 02, 135, pp. 1671-1684	<a href="https://doi.org/10.1007/s00122-022-04062-7">https://doi.org/10.1007/s00122-022-04062-7</a>	International	Published
2022	Musa A. I. I., Tsubo M., Ma S., Kurosaki Y., Ibaraki Y. and Ali-Babiker I. A., "Evaluation of WRF cumulus parameterization schemes for the hot climate of Sudan emphasizing crop growing seasons. ", Atmosphere, 2022. 04, 13, 4, pp. 572	<a href="https://doi.org/10.3390/atmos13040572">https://doi.org/10.3390/atmos13040572</a>	International	Published
2022	Mohamed I. E. S., Oe H., Kamal N. M., Mustafa H. M., Gorafi Y. S. A., Tahir I. S. A., Tsujimoto H. and Tanaka H., "Enhancing wheat flour quality through introgression of high-molecular-weight glutenin subunits from <i>Aegilops tauschii</i> accessions. ", Frontiers in Sustainable Food Systems, 2022, 887795	<a href="https://doi.org/10.3389/fsufs.2022.887795">https://doi.org/10.3389/fsufs.2022.887795</a>	International	Published
2022	Osman S. O. M., Saad A. S. I., Tadano S., Takeda Y., Yamasaki Y., Tahir I. S. A., Tsujimoto H. and Akashi K., "Probing differential metabolome responses among wheat genotypes to heat stress using fourier transform infrared-based chemical fingerprinting. ", Agriculture, 753	<a href="https://doi.org/10.3390/agriculture12060753">https://doi.org/10.3390/agriculture12060753</a>	International	Published
2022	Balla M. Y., Gorafi Y. S. A., Kamal N. M., Abdalla M. G. A., Tahir I. S. A. and Tsujimoto H., "Exploiting wild emmer wheat diversity to improve wheat A and B genomes in breeding for heat stress adaptation. ", Frontiers in Plant Science, 2022, 895742	<a href="https://doi.org/10.3389/fpls.2022.895742">https://doi.org/10.3389/fpls.2022.895742</a>	International	Published
2022	Mohamed I. E. S., Kamal N. M., Mustafa H. M., Abdalla M. G. A., Elhashimi A. M. A., Gorafi Y. S. A., Tahir I. S. A., Tsujimoto H. and Tanaka H., "Identification of Glu-D1 alleles and novel marker-trait associations for flour quality and grain yield traits under heat-stress environments in wheat lines derived from diverse accessions of <i>Aegilops tauschii</i> . ", International Journal of Molecular Sciences, 2022, 12034	<a href="https://doi.org/10.3390/ijms231912034">https://doi.org/10.3390/ijms231912034</a>	International	Published
2022	Iizumi T., Tsubo M., Maruyama A., Tahir I. S. A., Kurosaki Y. and Tsujimoto H., "High-temperature indicators for capturing the impacts of heat stress on yield: lessons learned from irrigated wheat in the hot and dry environment of Sudan. ", Climate Research, 2023, 89, pp. 85-98	<a href="https://doi.org/10.3354/cr01709">https://doi.org/10.3354/cr01709</a>	International	Published
2022	Mahjoob M. M. M., Kamal N. M., Gorafi Y. S. A. and Tsujimoto H., "Genome-wide association study reveals distinct genetic associations related to leaf hair density in two lineages of wheat-wild relative <i>Aegilops tauschii</i> . ", Scientific Reports, 2022. 10, 12, 1, pp. 17486	<a href="https://doi.org/10.1038/s41598-022-21713-3">https://doi.org/10.1038/s41598-022-21713-3</a>	International	Published
2023	Iizumi T., Tsubo M., Maruyama A., Tahir I. S. A., Kurosaki Y. and Tsujimoto H., "High-temperature indicators for capturing the impacts of heat stress on yield: lessons learned from irrigated wheat in the hot and dry environment of Sudan. ", Climate Research, 2023. 2, 89, pp. 85-98	<a href="https://doi.org/10.3354/cr01709">https://doi.org/10.3354/cr01709</a>	International	Published
2023	Ahmed M. I. Y., Kamal N. M., Gorafi Y. S. A., Abdalla M. G. A., Tahir I. S. A. and Tsujimoto H., "Heat stress-tolerant quantitative trait loci identified using backcrossed recombinant inbred lines derived from intra-specifically diverse <i>Aegilops tauschii</i> accessions. ", Plants, 2024. 1, 13, pp. 347	<a href="https://doi.org/10.3390/plants13030347">https://doi.org/10.3390/plants13030347</a>	International	Published
2023	Ahmed M. I. Y., Gorafi Y. S. A., Kamal N. M., Balla M. Y., Tahir I. S. A., Zheng L., Kawakami N. and Tsujimoto H., "Mining <i>Aegilops tauschii</i> genetic diversity in the background of bread wheat revealed a novel QTL for seed dormancy. ", Frontiers, 2023. 11, 14, pp. 1270925	<a href="https://doi.org/10.3389/fpls.2023.1270925">https://doi.org/10.3389/fpls.2023.1270925</a>	International	Published

2023	Mohammed A. A. A., Tsubo M., Ma S., Kurosaki Y., Ibaraki Y., Tahir I. S. A., Gorafi Y. S. A., Amani A.M.I. ans Tsujimoto H., "Micrometeorological Comparison of Canopy Temperature between Two Wheat Cultivars Grown under Irrigation in a Hot Environment in Sudan. ", <i>Agronomy</i> , 2023. 12, 13, 12, pp. 3032	<a href="https://doi.org/10.3390/agronomy13123032">https://doi.org/10.3390/agronomy13123032</a>	International	Published
2023	Mohammed A. A. A., Tsubo M., Kurosaki Y. and Ibaraki Y., "Characterization of the energy balance of wheat grown under irrigation in the hot arid environment of Sudan. ", <i>Atmosphere</i> , 2023. 12, 15, pp. 18	<a href="https://doi.org/10.3390/atmos15010018">https://doi.org/10.3390/atmos15010018</a>	International	Published
2024	Ibrahim, A. M. M., Hassan, A. O., Idris, A. A. M., Gorafi, Y. S. A., Tsujimoto, H. and Tahir, I. S. A., "Key factors influencing the adoption of improved wheat production technologies in the irrigated, heat-prone, arid environments of Sudan. ", <i>Sustainability</i> , 2024. 8,16, 15, pp. 6600	<a href="https://doi.org/10.3390/su16156600">https://doi.org/10.3390/su16156600</a>	International	Published
2024	Balla, M. Y., Kamal, N. M., Tahir, I. S. A., Gorafi, Y. S. A., Abdalla, M. G. A., and Tsujimoto, H., "Intraspecific variation for heat stress tolerance in wild emmer-derived durum wheat populations." <i>Frontiers in Plant Science</i> , 2025, 16, pp. 1523562	<a href="https://www.frontiersin.org/journals/plant-science/articles/10.3389/fpls.2025.1523562/full">https://www.frontiersin.org/journals/plant-science/articles/10.3389/fpls.2025.1523562/full</a>	International	Published
2024	Emam, A. I. I., Kamal, N. M., Gorafi, Y. S. A., Tahir, I. S. T., Balla, M. Y., Tsujimoto, H., and Ishii, T. "Enriched grain minerals in <i>Aegilops tauschii</i> -derived common wheat population under heat-stress environment." <i>Scientific Reports</i> , 2025, 15, pp. 5624	<a href="https://www.nature.com/articles/s41598-025-89144-4">https://www.nature.com/articles/s41598-025-89144-4</a>	International	Published
2024	Grafi, Y. S. A., Tahir, I. S. A., and Tsujimoto, H., "A multiple synthetic derivatives population for mining <i>Ae. tauschii</i> traits and genes in a background of common wheat." <i>Journal of Plant Registration</i> , 2025	<a href="https://access.onlinelibrary.wiley.com/doi/10.1002/plr2.20424">https://access.onlinelibrary.wiley.com/doi/10.1002/plr2.20424</a>	International	Published

(B) Original articles other than above (A)

Fiscal Year	Paper information	DOI Code	Domestic/International	Status
2019	Mega R., Tsujimoto H. and Okamoto M., "Genetic manipulation of abscisic acid receptors enables modulation of water use efficiency. ", <i>Plant Signaling &amp; Behavior</i> , 2019. 01, 14, pp. e1642039	<a href="https://doi.org/10.1080/15592324.2019.1642039">https://doi.org/10.1080/15592324.2019.1642039</a>	International	Published
2019	Vaidya A. S., Helander J. D. M., Peterson F. C., Elzinga D., Dejonghe W., Kaundal A., Park S. Y., Xing Z., Mega R., Takeuchi J., Khanderahoo B., Bishay S., Volkman B. F., Todoroki Y., Okamoto M. and Cutler S. R., "Dynamic control of plant water use using designed ABA receptor agonists. ", <i>Science</i> , 2019. 10, 3666464, pp. aaw8848	<a href="https://doi.org/10.1126/science.aaw8848">https://doi.org/10.1126/science.aaw8848</a>	International	Published
2020	Itam M. O., Abdelrahman M., Yamasaki Y., Mega R., Gorafi Y. S. A., Akashi K. and Tsujimoto H., " <i>Aegilops tauschii</i> introgressions improve physio-biochemical traits and metabolite plasticity in bread wheat under drought stress. ", <i>Agronomy</i> , 2020. 10, 10, pp. 1588	<a href="https://doi.org/10.3390/agronomy10101588">https://doi.org/10.3390/agronomy10101588</a>	International	Published
2020	Itam M. O., Mega R., Tadano S., Abdelrahman M., Matsunaga S., Yamasaki Y., Akashi K. and Tsujimoto H., "Metabolic and physiological responses to progressive drought stress in bread wheat. ", <i>Scientific Reports</i> , 2020. 10, 10, pp. 1-14	<a href="https://doi.org/10.1038/s41598-020-74303-6">https://doi.org/10.1038/s41598-020-74303-6</a>	International	Published
2021	Matsunaga S., Yamasaki Y., Toda Y., Mega R., Akashi K. and Tsujimoto H., "Stage-specific characterization of physiological response to heat stress in the wheat cultivar Norin 61. ", <i>International Journal of Molecular Sciences</i> , 2021. 01, 2213, pp. 6942	<a href="https://doi.org/10.3390/ijms22136942">https://doi.org/10.3390/ijms22136942</a>	International	Published
2021	Itam M. O., Wahbi A., Fujimaki H. and Tsujimoto H., "Transpiration response of two bread wheat lines differing in drought resilience and their backcross parent under dry-down conditions. ", <i>Breeding Science</i> , 2021. 11, 715, pp. 575-583	<a href="https://doi.org/10.1270/jsbbs.20154">https://doi.org/10.1270/jsbbs.20154</a>	International	Published
2021	Matsunaga S., Yamasaki Y., Mega R., Toda Y., Akashi K. and Tsujimoto H., "Metabolome profiling of heat priming effects, senescence, and acclimation of bread wheat induced by high temperatures at different growth stages. ", <i>Molecular Sciences</i> , 2021. 12, 2223, pp. 13139	<a href="https://doi.org/10.3390/ijms222313139">https://doi.org/10.3390/ijms222313139</a>	International	Published
2021	Vaidya A. S., Peterson F. C., Eckhardt J., Xing Z., Park S. Y., Dejonghe W., Takeuchi J., Pri-Tal O., Faria J., Elzinga D., Volkman B. F., Todoroki Y., Mosquna A., Okamoto M. and Cutler S. R., "Click-to-lead design of a picomolar ABA receptor antagonist with potent activity in vivo. ", <i>PNAS</i> , 2021. 09, 11838, pp. e2108281118	<a href="https://doi.org/10.1073/pnas.2108281118">https://doi.org/10.1073/pnas.2108281118</a>	International	Published
2023	Nozoye T., Gorafi Y. S. A., Ube N., Wang F., Nakanishi H., Ishihara A., Ishii T. and Tsujimoto H., "Diversity in the genome of <i>Aegilops tauschii</i> a wild wheat relative to generate Fe-biofortified and Fe-deficiency-tolerant wheat. ", <i>Plant Genetic Resources</i> , 2023. 7, 1, 21, pp. 58-70	<a href="https://doi.org/10.1017/S1479262123000424">https://doi.org/10.1017/S1479262123000424</a>	International	Published
2023	Mega R., Kim J.-S., Tanaka H., Ishii T., Abe F. and Okamoto M., "Metabolic and transcriptomic profiling during wheat seed development under progressive drought conditions. ", <i>Scientific Reports</i> 2023. 11, 13 pp. 15001	<a href="https://doi.org/10.1038/s41598-023-42093-2">https://doi.org/10.1038/s41598-023-42093-2</a>	International	Published
2024	Weng, Y., Mega, R., Abe, F., Tsujimoto, H. and Okamoto, M., "Metabolic profiles in drought-tolerant wheat with enhanced abscisic acid sensitivity. ", <i>PLOS ONE</i> , 2024. 7, 19, 7, pp. e0307393	<a href="https://doi.org/10.1371/journal.pone.0307393">https://doi.org/10.1371/journal.pone.0307393</a>	International	Published
2024	Abdelrahman, M., Gorafi, Y. S. A., Suliman, S., Jogaiah, S., Gupta, A., Tsujimoto, H., Nguyen, H. T., Herrera-Estrella, L., and Tran, L.-S. P., "Wild grass-derived alleles represent a genetic architecture for the resilience of modern common wheat to stresses. ", <i>The Plant Journal</i> , 2024. 6, 119, 4, pp. 1685-1702	<a href="https://doi.org/10.1111/tpl.16887">https://doi.org/10.1111/tpl.16887</a>	International	Published
2024	Toda-Matsunaga, S., Toda, Y., Mega, R., Tadano, S., Alyza, M., Yamasaki, Y., Akashi, K., and Tsujimoto, H. "Wheat seed exposed to heat during formation can germinate at high temperature.", <i>Frontiers in Plant Science</i> , 2025	<a href="https://www.frontiersin.org/journals/plant-science/articles/10.3389/fpls.2025.1539926/full">https://www.frontiersin.org/journals/plant-science/articles/10.3389/fpls.2025.1539926/full</a>	International	Published

(C) Book and movie

Fiscal Year	Paper information	DOI Code	Domestic/International	Status
2020	Technical support for sustainable wheat production in Sudan 1 (in Arabic)	<a href="https://www.youtube.com/watch?v=JAVfzd9FYgY">https://www.youtube.com/watch?v=JAVfzd9FYgY</a>	Movie	released
2020	Technical support for sustainable wheat production in Sudan 2 (in Arabic)	<a href="https://www.youtube.com/watch?v=b7sPvZl_MEk">https://www.youtube.com/watch?v=b7sPvZl_MEk</a>	Movie	released
2020	Technical support for sustainable wheat production in Sudan 3 (in Arabic)	<a href="https://www.youtube.com/watch?v=FSHoTC258Hk">https://www.youtube.com/watch?v=FSHoTC258Hk</a>	Movie	released
2020	Technical support for sustainable wheat production in Sudan 4 (in Arabic)	<a href="https://www.youtube.com/watch?v=HTVAeGrW60Q">https://www.youtube.com/watch?v=HTVAeGrW60Q</a>	Movie	released
2020	Technical support for sustainable wheat production in Sudan 5 (in Arabic)	<a href="https://www.youtube.com/watch?v=hiW0LSiaNqg">https://www.youtube.com/watch?v=hiW0LSiaNqg</a>	Movie	released
2022	Introductory episode about SATREPS wheat project (in Arabic with Japanese subtitle)	<a href="https://www.youtube.com/watch?v=hxAv2FgDwbk">https://www.youtube.com/watch?v=hxAv2FgDwbk</a>	Movie	released

2024	Tsujimoto, H., Gorafi, Y. S. A., Tahir, I. S. A., "Wheat breeding and quality seed dissemination in hot and dry agroecosystems in Sudan" In : Use of plant genetic resources and information for the crop production in developing countries under global warming and extreme environment conditions - Achievements and perspectives from SATREPS project		Book	in press
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## Annex 2-2.2. List of oral and poster presentations

### (A) Presentation co-authored with the research team of the partner country

Fiscal year	Domestic/ International	Presentation information	Invited/ Oral/ Poster
2018	International	Tsujimoto H, Gorafi YSA, Kim JS, Elbashir AAE, Tahir I: Development of innovative germplasm for wheat breeding for dry and heat-prone agro-environment of Sub-Saharan Africa. 13th International Conference on Development of Drylands. Feb 11-14, 2019 (Jodhpur,	Invited
2019	International	Tahir ISA, Meheesi SEM, Mohamed IES, Gorafi YSA, Tsujimoto H, Tadesse W, Bassi FM, Amri A: Wheat Improvement for the Heat Prone Agro-ecologies of Sudan and Sub-Saharan Africa: Breeding and Pre-breeding Approaches for Climate Change Resilient Varieties, 1st International Expert Workshop on Pre-Breeding Utilizing Crop Wild Relatives, ICARDA, Rabat,	Invited
2019	International	Tsujimoto H, Gorafi YSA, Tahir ISA: Extensive wheat germplasm enhancement to secure food under climate change, International Conference of Plant Chromosome Engineering and Functional Genomics for Breeding, Beijing, China, June 3-5, 2019.	Invited
2019	International	Tsujimoto H1, Gorafi YSA1,2, Kim J-S3 (1: Tottori Univ., 2: ARC, Sudan, 3: Riken) Wheat population for pure line selection of useful traits from <i>Aegilops tauschii</i> , 1st International Wheat Congress, Saskatoon, Canada, July 21-26, 2019.	Poster
2019	International	Gorafi YS, Elhashimi AM, Kim JS, Kamal NM, Yamasaki, Tahir IS, Tsujimoto H: 1st International Wheat Congress, Saskatoon, Canada, July 21-26, 2019.	Poster
2019	Domestic	マハジューブマジン, 陳 泰伸, ゴラフィヤシル, 岩田 洋佳, カマルナスリン, 松岡 由浩, 辻本 壽: コムギ育種のための新規変異を探索するためのコムギ関連種 <i>Aegilops tauschii</i> の 343 系統の形態生理学的形質、日本育種学会第136回講演会、奈良、2019年9月6日、7日。	Poster
2019	Domestic	エルハデイ ジャミラ, カマル ナスリーン, 山崎 裕司, ゴラフィヤシル, 高田 兼則, 田中 裕之, 辻本 壽: 合成コムギ派生集団を用いた、ゲノムワイド関連解析によるコムギ種子硬軟質の研究、日本育種学会第136回講演会、奈良、2019年9月6日、7日。	Poster
2019	Domestic	Mazin M. M. Mahjoob, Y. S. A. Gorafi, N. M. Kamal, Y. Yamasaki1, Y. Matsuoka and H. Tsujimoto: GWAS for exploiting morphophysiological diversity that closely related to the yield in wheat related-species <i>Aegilops tauschii</i> to enhance adaptation in wheat, 日本育種学会第137回講演会、東京、2020年3月28日、29日。	Oral
2019	Domestic	Michael Itam, Ryosuke Mega, Yuji Yamasaki, Mostafa Abdelrahman, Yasir Gorafi, Hisashi Tsujimoto1: Metabolic and physiological responses of wheat to progressive drought stress at the flowering stage: from Norin 61 to multiple synthetic derivative (MSD) lines, 日本育種学会第137回講演会、東京、2020年3月28日、29日。	Oral
2019	International	Iizumi T, Tsubo M, Babiker IAA, Kurosaki Y. Simulating the two different heat-tolerant spring wheat varieties grown in Sudan using CYGMA global gridded crop model. iCROP2020, Montpellier (France), 2-5 February 2020.	Oral
2020	Domestic	山崎裕司、Y. Gorafi、I. Tahir、辻本壽: 未利用遺伝資源を用いたリン節肥性コムギの特徴、第12回中国地域育種学談話会、オンライン、2020年12月12日	Oral
2020	Domestic	M. Y. B. Abdalla, Y. S. A. Gorafi, N. M. Kamal, I. Tahir, H. Tsujimoto: Harnessing the genetic diversity of wild emmer wheat for genetic improvement of durum wheat, 第12回中国地域育種学談話会、オンライン、2020年12月12日	Oral
2020	Domestic	辻本壽、田中裕之、明石欣也、坪充、岡本昌憲、Y. Gorafi、I. Tahir、H. M. Mustafa、A. I. Saad、I. A. A. Babiker、A. M. Idris: サブサハラアフリカの乾燥・高温耐性育種のための遺伝資源拡大、第15回ムギ類研究会、オンライン、2020年12月26日	Invited
2020	Domestic	M. Itam, Y. Gorafi, I. Tahir, H. Tsujimoto: Physio-agronomic and metabolite profiling reveal the role of <i>Aegilops tauschii</i> introgressions in wheat lines under drought stress, 第15回ムギ類研究会、オンライン、2020年12月26日	Oral
2020	Domestic	M. Itam, Y. Gorafi, I. Tahir, H. Tsujimoto: QTL hotspots for combined heat and drought stress resilience in bread wheat grown in Sudanese field, 第139回日本育種学会講演会、オンライン、2021年3月20・21日	Oral
2021	Domestic	M. Y. Balla, Y. S. A. Gorafi, N. M. Kamal, I. Tahir, H. Tsujimoto: デュラムコムギ派生集団: 野生エンマーコムギ由来の新たな遺伝資源。日本育種学会第140回講演会、オンライン、2021年9	Oral

2022	Domestic	竹田佳生、Osman S. O. M.、只野翔太、深内百合子、山崎裕司、Saad A. S. I.、Tahir I. S. A.、辻本壽、明石欣也: FTIRケモメトリックスと化学的分画によるコムギの高温応答プロファイリング、日本農芸化学会中四国支部第62回例会、オンライン、2022年6月4日	Oral
2022	International	Monir I. Y. A., Gorafi Y. S. A., Kamal N. M., Tahir I. S. A. and Tsujimoto H.: Identification of a novel QTL controlling seed dormancy in wheat originated from <i>Aegilops tauschii</i> . 2nd International Wheat Congress, China (Sep., 2022)	Oral
2022	International	Osman S. O. M., Saad A. S. I., Tadano S., Takeda Y., Konaka T., Yamasaki Y., Tahir I. S. A., Tsujimoto H. and Akashi K.: Profiling wheat ( <i>Triticum aestivum</i> L.) biochemical responses to heat stress by fourier transform infrared spectroscopy. the 2nd International Wheat	Oral
2022	International	Balla M. Y., Gorafi Y. S. A., Kamal N. M., Modather G. A. A., Tahir I. S. A. and Tsujimoto H.: Exploiting wild emmer wheat diversity to improve wheat A and B genomes in breeding for heat stress adaptation. 2nd International Wheat Congress, China (Sep., 2022)	Poster
2022	International	Mohamed I. E. S., Oe H., Kamal N. M., Mustafa H. M., Gorafi Y. S. A., Tahir I. S. A., Tsujimoto H. and Tanaka H.: Introgression of high-molecular-weight glutenin subunits from <i>Aegilops tauschii</i> improved wheat flour quality. 2nd International Wheat Congress, China (Sep.,	Poster
2022	International	Gorafi Y. S. A., Tahir I. S. A. and Tsujimoto H.: Extensive exploration of <i>Aegilops tauschii</i> genetic diversity for improvement of bread wheat stress tolerance. 2nd International Wheat Congress, China (Sep., 2022)	Poster
2022	International	Sakuma S., Tahir I. S. A., Zhuo Su, Gorafi, Y. S. A., Nasuda S. and Tsujimoto H.: Elucidation of wheat grain shattering mechanism in heat-prone drylands. 2nd International Wheat Congress, China (Sep., 2022)	Poster
2022	Domestic	竹田佳生、Osman S.、只野翔太、深内百合子、山崎裕司、Saad A. S.、Tahir Y. S. A.、辻本壽、明石欣也: FTIR 計量化学と化学的分画によるコムギの高温応答プロファイリング、第39回日本植物バイオテクノロジー学会、大阪府堺市、2022年9月10-13日	Oral
2022	Domestic	Monir I. Y. A., Gorafi Y. S. A., Kamal N. M., Tahir I. S. A. and Tsujimoto H.: Identification of a novel QTL controlling seed dormancy in wheat originated from <i>Aegilops tauschii</i> . 日本育種学会第142回講演会、北海道帯広市、2022年9月23-25日	Poster
2022	Domestic	Balla M. Y., Gorafi Y. S. A., Kamal N. M., Abdalla M. G. A., Tahir I. S. A. and Tsujimoto H.: Interspecific variation and genome wild association analysis for heat stress tolerance adaptation in wild emmer wheat, 日本育種学会第142回講演会、北海道帯広市、2022年9月23-	Oral
2022	Domestic	Balla M. Y., Kamal N. M., Gorafi Y. S. A., Tahir I. S. A. and Tsujimoto H.: Exploration of heat-stress tolerance allele from wild emmer wheat intraspecific variation for wheat breeding、第14回中国地域育種談話会、山口県山口市、2022年12月10.11日	Poster
2022	Domestic	Ahmed M. I. Y., Gorafi Y. S. A., Kamal N. M., Tahir I. S. A. and Tsujimoto H.: Heat tolerance and seed Dormancy using wheat BILs population possessing <i>Aegilops tauschii</i> chromosome segments、第14回中国地域育種談話会、山口県山口市、2022年12月10.11日	Poster
2022	Domestic	Emam A. I. I., Gorafi Y. S. A., Ishii T. and Tsujimoto H.: Sustainable wheat production under climate change: interventions for increased NUE of Bread Wheat、第14回中国地域育種談話会、山口県山口市、2022年12月10-11日	Poster
2022	Domestic	竹田佳生、Osman S.、只野翔太、山崎友渡、Saad A. S.、Tahir I. S. A.、辻本壽、明石欣也: FTIRケモメトリックスによるコムギ高温応答の解析、第64回日本植物生理学会、宮城県仙台市、2023年3月10-17日	Oral
2023	International	Tsujimoto H., Gorafi Y. S. A. and Tahir I. S. A.: Development of heat- and drought-tolerant wheat germplasm for Africa utilizing genetic diversity in <i>Aegilops tauschii</i> . コムギ研究の新展開: 100年の研究史を反映した生物遺伝資源とゲノミクス、そして未来へ. Kyoto, Japan	Poster
2023	International	Tsujimoto H., Tahir I. S. A. and Gorafi Y. S. A.: Sustaining wheat production through the development of climate-smart innovative technologies for the dry and heat prone agro-ecologies of Sudan and sub-saharan Africa. The African Plant Breeders Association Conference	Poster
2023	International	Ahmed M. I. Y., Kamal N. M., Gorafi Y. S. A., Abdala M. G. A., Tahir I. S. A. and Tsujimoto H.. Ahmed, M. I. Y., Kamal, N. M., Gorafi, Y. S. A., Abdala, M. G. A., Tahir, I. S. A. and Tsujimoto, H.: Identification of QTLs for heat stress tolerance in wheat using backcrossed recombinant inbred lines. The African Plant Breeders Association Conference 3rd Edition. Morocco (Oct., 2023)	Poster

2023	International	Tahir I. S. A., Gorafi Y. S. A., Idris A. A. M., Saad A. S. I., Mustafa H. M., Elbashir A. A. E., Elsheikh O., Elhashimi A. M. A., Elbashier E. M. E. and Tsujimoto H.: Seed security for adaptation to climate change and boosting wheat productivity in hot and dry environments. The African Plant Breeders Association Conference 3rd Edition. Morocco (Oct., 2023)	Poster
2023	International	Gorafi Y. S. A., Tahir I. S. A. and Tsujimoto H.: A story from the gene bank to the field. The African Plant Breeders Association Conference 3rd Edition. Morocco (Oct., 2023)	Poster
2023	Domestic	Balla M. Y., Kamal N. M., Gorafi Y. S. A., Abdalla M. G. A., Tahir I. S. A., Tsujimoto H.: Exploration of wild emmer wheat intraspecific heat stress tolerance variation in a background of durum wheat、日本育種学会第144回講演会(兵庫県神戸市)(2023年9月)	Poster
2023	Domestic	Balla M. Y., Kamal N. M., Gorafi Y. S. A., Abdalla M. G. A., Tahir I. S. A. and Tsujimoto H.: Exploration of wild emmer wheat intraspecific heat stress tolerance variation in a background of durum wheat、第15回中国地域育種談話会(鳥取県鳥取市)(2023年9月)	Poster
2023	Domestic	Emam. A. I. I., Gorafi Y. S. A., Tahir I. S. A., Ishii T. and Tsujimoto H.: Sustainable wheat production under climate change: interventions for increased NUE of Bread Wheat、第15回中国地域育種談話会(鳥取県鳥取市)(2023年9月)	Poster
2023	Domestic	山崎裕司、Gorafi Y. S. A., Tahir I. S. A., 辻本壽: コムギ未利用遺伝資源を用いたリン欠乏耐性系統選抜と耐性系統の生理学的解析、第256回日本作物学会講演会(佐賀県佐賀市)(2023年9月)	Oral
2023	Domestic	竹田佳生、Osman S. O. M., 只野翔太、深内百合子、山崎裕司、Saad A. S. I., Tahir I. S. A., 辻本壽、明石欣也: 中赤外分光法による植物メタボロミクスーコムギ高温ストレス応答への適用、第40回日本植物バイオテクノロジー学会(千葉[ハイブリッド])大会、シンポジウム(千葉県千葉市)(2023年9月)	Oral
2023	Domestic	Tahir I. S. A.: Enhancing genetic gain and improving crop resilience to climate change by unraveling genotype x environment x management interactions、共同利用、共同研究拠点 鳥取大学乾燥地研究センター 令和5年度共同研究発表会(鳥取県鳥取市)(2023年12月)	Poster
2023	Domestic	竹田佳生、Salma O.M. Osman, 只野翔太、山崎友渡、Abu Sefyan I. Saad, Izzat S.A. Tahir, 山崎裕司、辻本壽、明石欣也: FTIR計量化学手法と化学的分画によるコムギ葉の高温ストレス応答の解析、日本農芸化学会中四国支部例会(山口県宇部市)(2023年6月)	Oral
2023	Domestic	竹田佳生、Salma O.M. Osman, 只野翔太、山崎友渡、Abu Sefyan. I. Saad, Izzat S.A. Tahir, 山崎裕司、辻本壽、明石欣也: 高温ストレスにより誘導されるコムギ葉の細胞壁成分の物理化学的变化の可能性、日本農芸化学会中四国支部例会(高知県高知市)(2023年9月)	Oral
2024	International	Tahir, I. S. A., Gorafi, Y. S. A., Idris, A. A. M., Elbashir, A. A. E., Saad, A. S. I., Mustafa, H. M., Elhashimi, A. M. A., Elsheikh, O., Elbashier, E. M. E., and Tsujimoto, H.: Seed production partnerships for sustainable wheat production and enhanced food security in hot, dry environments, the 3rd International Wheat Congress, Australia (Sep., 2024)	Poster
2024	International	Gorafi, Y. S. A., Tahir, I. S. A. and Tsujimoto, H.: Can eastern wheat break the yield-barrier: adaptation of Japanese wheat cultivars to hot and dry environments, the 3rd International Wheat Congress, Australia (Sep. 2024)	Poster
2024	Domestic	Tahir, I. S. A.: Seeding resilience: strategic seed production partnerships for sustainable wheat cultivation and enhanced food security in hot and dry environments、共同利用・共同研究拠点 鳥取大学乾燥地研究センター 令和6年度共同研究発表会(鳥取県鳥取市)(2024年12月)	Poster
2024	Domestic	武田浩子、山崎裕司、松永幸子、Absefian Saad、辻本壽、明石欣也: 高温ストレスに対するコムギMSD系統群の遺伝子発現応答の比較解析日本農芸化学会中四国支部第70回講演会(広島県東広島市)(2025年1月25日)	Oral

(B) Presentation other than above (A)

Fiscal year	Domestic/ International	Presentation information	Invited/ Oral/ Poster
2018	Domestic	辻本壽: 新研究プロジェクト(SATREPS Sudan)紹介〜サブサハラアフリカの高温・乾燥農業生態系に適応するコムギ品種改良をめざして。第13回ムギ類研究会。2018年11月26・27日(横浜市立大学)。	Poster
2018	Domestic	大江陽香, 辻本壽, 田中裕之: 高温ストレス下でも小麦粉品質低下を起こさない高分子量グルテニンサブユニットの探索、第10回中国地域育種談話会、2018年12月15・16日(鳥取大学)。	Poster

2019	International	Tsujimoto H: Can we find abiotic stress tolerance in wheat related-wild species? - Experiences and lessons learned in pre-breeding of wheat with drought and heat stress tolerance, 1st International Expert Workshop on Pre-Breeding Utilizing Crop Wild Relatives, ICARDA, Rabat, Morocco, April 24-26.	Invited
2019	International	Mega R, Abe F, Kim JS, Tsujimoto, Kikuchi J, Okamoto M: Water-saving Wheat: Tuning water use efficiency and drought tolerance using ABA receptors. 1st International Wheat Congress, Saskatoon, Canada, July 21-26, 2019.	Oral
2019	International	Mahjoob M, Shen, Gorafi Y, Yamasaki Y, Kamal N, Abdelrahman M, Iwata H, Tsujimoto H: New insights into Aegilops tauschii genetic diversity and morpho-physiological variation, 1st International Wheat Congress, Saskatoon, Canada, July 21-26, 2019.	Poster
2019	International	Itam M, Matsunaga S, Mega R, Yamasaki Y, Tsujimoto H: Metabolic and physiological response of wheat to progressive drought stress at the flowering stage, 1st International Wheat Congress, Saskatoon, Canada, July 21-26, 2019.	Oral
2019	Domestic	妻鹿 良亮, 石井 孝佳, 安倍 史高, 菊地淳, 坪井 裕理, 田中 裕之, 岡本 昌憲, 辻本壽: 節水型耐乾性コムギは乾燥ストレスによる種子品質低下を緩和する。日本育種学会第136回講演会、奈良、2019年9月6日・7日。	Oral
2019	Domestic	松永幸子・山崎裕司・妻鹿良亮・辻本壽: パンコムギの生育ステージ特異的高温ストレス応答: 幼苗期のストレス応答は登熟期まで続く。日本育種学会第137回講演会、東京、2020年3月28日	Oral
2019	Domestic	明石欣也、山田みな美、只野翔大、留森寿士、辻本壽: 乾燥地のストレス耐性植物群の表皮ワックス組成と光反射能との関係、第92回日本生化学会大会、横浜、2019年9月19日	Poster
2019	Domestic	山田みな美、只野翔大、留森寿士、辻本壽、明石欣也、乾燥地植物の光反射特性および表皮に蓄積する化合物プロファイルの解析、日本生化学会中国・四国支部例会、山口県宇部市、2019	Oral
2019	International	Okamoto M.: Tuning water use efficiency and drought tolerance in wheat using ABA receptors, 23th The International Plant Growth Substances Association Conference	Invited
2019	domestic	岡本昌憲: アブシシン酸感受性の向上によるコムギの水利用効率と耐乾性の改良、第61回日本育種学会シンポジウム、奈良、2019年9月	Invited
2020	International	Okamoto M. Tuning water use efficiency and drought tolerance in wheat using abscisic acid receptors, International Workshop on Optics, Biology, and Related Technologies, Utsunomiya, 26 February, 2021	Invited
2020	Domestic	松永幸子、アリザメグミ、山崎裕司、明石欣也、辻本壽: 生育時の高温処理がパンコムギの高温発芽能力と脂肪酸組成に及ぼす影響、中国地域育種談話会、オンライン、2020年12月12日	Oral
2020	Domestic	内田孝三、辻本壽: チップ栽培を利用したコムギのスピードブリーディングについて、第12回中国地域育種学談話会、オンライン、2020年12月12日	Oral
2020	Domestic	塚田美彩子、辻本壽: パンコムギの高温発芽能力に及ぼす遺伝子および環境の影響、第12回中国地域育種学談話会、オンライン、2020年12月12日	Oral
2020	Domestic	松永幸子: パンコムギの生育ステージ特異的高温・乾燥ストレス応答、国際乾燥地研究教育機構 研究プロジェクトワークショップ、鳥取、2020年12月25日	Oral
2020	Domestic	岡本昌憲: アブシシン酸受容体があるたらす病害抵抗性機構の解析、第15回ムギ類研究会、オンライン、2020年12月26日	Poster
2020	Domestic	松永幸子、戸田悠介、妻鹿良亮、山崎裕司、辻本壽: 多様な高温環境に適応するパンコムギ系統の選抜に向けたマルチオミクス解析。第139回日本育種学会、オンライン、2021年3月20・21日	Oral
2020	Domestic	山崎裕司、Y. Gorafi, I. Tahir、辻本壽: 未利用遺伝資源を用いた高リン利用効率コムギ系統の特徴、第139回日本育種学会講演会、オンライン、2021年3月20・21日	Oral
2020	International	Okamoto M.: Tuning water use efficiency and drought tolerance in wheat using abscisic acid receptors, International Workshop on Optics, Biology, and Related Technologies (Utsunomiya) 2021年2月26日	Invited
2021	Domestic	塚田美彩子、松永幸子、只野翔大、山崎裕司、Yasir S.A. Gorafi、新田みゆき、那須田周平、明石欣也、辻本壽: パンコムギの高温発芽能力に関する遺伝・整理・生化学的研究。第16回ムギ類研究会、オンライン、2021年12月24日。	Poster
2021	Domestic	塚田美彩子、松永幸子、只野翔大、山崎裕司、Yasir S.A. Gorafi、新田みゆき、那須田周平、明石欣也、辻本壽: パンコムギの高温発芽耐性とその遺伝分析。第141回日本育種学会講演会、オンライン、2022年3月20・21日	Oral
2021	Domestic	松永幸子、山崎裕司、Yasir S.A. Gorafi、戸田啓介、辻本壽: 高温ストレス耐性パンコムギ育種選抜に向けた代謝物質プロファイリング。第141回日本育種学会講演会、オンライン、2022年3	Poster

2021	Domestic	山崎裕司、松永幸子、戸田啓介、Yasir S.A. Gorafi、辻本壽：高温耐性パンコムギ育種選抜に向けた生理学的解析。第141回日本育種学会講演会、オンライン、2022年3月20・21日	Poster
2021	Domestic	Michael Itam, Hisashi Tsujimoto：パンコムギの暑さと干ばつに強い複合育種：対立遺伝子、代謝産物、水保存機構。第141回日本育種学会講演会、オンライン、2022年3月20・21日	Poster
2021	Domestic	嶋崎太一、金俊植、妻鹿良亮、安倍史高、宮本皓司、山根久和、吉田健太郎、岡本昌憲：アブシシン酸受容体がもたらすコムギ病害抵抗性機構の分子解析。植物化学調節学会第54回大会（web）	Oral
2021	Domestic	Weng Y.、金俊植、妻鹿良亮、辻本壽、岡本昌憲：コムギにおける乾燥ストレス応答に対する代謝産物の包括的解析。第63回日本植物生理学会年会、（つくばweb）2022年3月22-24日	Oral
2021	Domestic	Weng Y.、金俊植、妻鹿良亮、辻本壽、岡本昌憲：コムギにおける乾燥ストレス応答に対する代謝産物の包括的解析。日本育種学会第141回講演会（京都web）2022年3月20-21日	Poster
2021	Domestic	嶋崎太一、金俊植、妻鹿良亮、安倍史高、宮本皓司、山根久和、二瓶賢一、吉田健太郎、岡本昌憲：コムギにおけるアブシシン酸受容体がもたらすうどんこ病菌抵抗性形質の分子生物学的解析。日本育種学会第141回講演会（京都web）2022年3月20-21日	Oral
2021	Domestic	佐藤佑樹、嶋崎太一、Weng Y.、金俊植、二瓶賢一、岡本昌憲：うどんこ病感染過程におけるコムギの代謝産物蓄積と植物ホルモン含有量の経時的変化の解析。日本育種学会第141回講演会（京都web）2022年3月20-21日	Poster
2021	Domestic	岡本昌憲：植物ホルモン・アブシシン酸の機能調節による耐乾性制御、日本学術会議公開シンポジウム（Web）2021年12月4日	Invited
2022	International	Gorafi Y. S. A.: Extensive exploration of wild relatives diversity for wheat breeding: from the gene bank to the field. Webinars by the International Wheat Genome Sequencing Consortium, Online (Jul., 2022)	Invited
2022	International	Itam M. O. and Tsujimoto H.: Understanding combined heat and drought tolerance in bread wheat: agronomic and physiological approach. 2nd International Wheat Congress, China	Poster
2022	International	Matsunaga S., Yamasaki Y., Toda Y., Mega R., Akashi K. and Tsujimoto H.: Stage-specific characterization of physiological and metabolic response to heat stress in the wheat cultivar Norin 61. 2nd International Wheat Congress, China (Sep., 2022)	Poster
2022	International	Weng Y., Kim J.-S., Mega R., Tsujimoto H. and Okamoto M.: Comprehensive analysis of metabolites in response to drought stress in wheat. 2nd International Wheat Congress, China	Poster
2022	Domestic	Weng Yuanjie、金俊植、妻鹿良亮、辻本壽、岡本昌憲：コムギにおける乾燥ストレス応答に対する代謝産物の包括的解析、植物化学調節学会第57回大会（福井県）（2022年11月）	Poster
2022	Domestic	嶋崎太一、二瓶賢一、岡本昌憲：コムギABA受容体によるサリチル酸およびN-ヒドロキシピペコリン酸生合成酵素遺伝子の発現制御、植物化学調節学会第57回大会（福井県）（2022年11月）	Poster
2022	Domestic	辻本壽、田中裕之、笠谷信明：タルホコムギ由来の休眠性と高分子量グルテニン遺伝子 Glu-D1d 遺伝子をパンコムギ品種「農林61号」に導入した系統の開発、第17回コムギ類研究会（茨城県つくば市）（2022年12月）	Poster
2022	Domestic	嶋崎太一、金俊植、妻鹿良亮、安倍史高、二瓶賢一、吉田健太郎、岡本昌憲：コムギのアブシシン酸受容体によるサリチル酸およびN-ヒドロキシピペコリン酸生合成酵素遺伝子の発現制御機構の解明、第17回コムギ類研究会（茨城県つくば市）（2022年12月）	Poster
2022	Domestic	小野輝久、岸井正浩、平井優美、辻本壽、岡本昌憲：オオハマニンニク染色体添加系統パンコムギにおけるメタボローム解析、第17回コムギ類研究会（茨城県つくば市）（2022年12月）	Poster
2022	Domestic	妻鹿良亮、金俊植、石井孝佳、田中裕之、安倍史高、岡本昌憲：成熟途上コムギ種子における乾燥ストレスが及ぼす分子的影響の包括的解析、第17回コムギ類研究会（茨城県つくば市）（2022年12月）	Poster
2023	Domestic	中村木葉里、佐久間俊：ヒトツブコムギの粒数と粒重のトレードオフを制御するQTLs、第18回コムギ類研究会、（滋賀県）（2023年12月）	Poster
2023	Domestic	小野輝久、岸井正浩、佐藤心郎、平井優美、辻本壽、岡本昌憲：オオハマニンニク染色体添加系統パンコムギにおける形質変化に関する研究、日本育種学会第145回講演会（東京都文京区）	Poster
2023	Domestic	Weng Yuanjie、嶋崎太一、妻鹿良亮、安倍史高、金俊植、吉田健太郎、二瓶賢一、岡本昌憲：コムギにおけるアブシシン酸受容体を介した病害抵抗性に関する分子生物学的解析、日本育種学会第145回講演会（東京都文京区）（2024年3月）	Poster
2023	Domestic	佐藤佑樹、Weng Yuanjie、嶋崎太一、二瓶賢一、吉田健太郎、岡本昌憲：コムギうどんこ病菌感染過程における病害抵抗性遺伝子と生理活性分子の経時的変化の解析、日本育種学会第145回講演会（東京都文京区）（2024年3月）	Poster
2023	Domestic	平田駿一郎、横山聡太郎、辻本壽、妻鹿良亮：コムギTILLING集団からの節水型耐乾性系統の選抜および生理学的解析、日本育種学会第144回講演会（兵庫県神戸市）（2023年9月）	Poster

2023	Domestic	小野輝久、岸井正浩、平井優美、辻本壽、岡本昌憲: オオハマニンニク染色体添加系統パンコムギにおけるメタボローム解析、日本育種学会第144回講演会(兵庫県神戸市)(2023年9月)	Poster
2023	Domestic	Weng Yuanjie、島崎太一、佐藤佑樹、二瓶賢一、金俊植、岡本昌憲: コムギうどんこ病菌感染における病害応答性遺伝子発現と植物ホルモンの経時的变化の解析、植物化学調節学会第58回大会(神奈川県川崎市)(2023年11月)	Poster
2023	Domestic	平田駿一郎、横山聡太郎、辻本壽、妻鹿良亮: コムギTILLING 集団からの節水型耐乾性系統の選抜および生理学的解析、第15回中国地域育種談話会(鳥取県鳥取市)(2023年9月)	Poster
2023	Domestic	日名弘貴、松岡由浩、石井孝佳、妻鹿良亮: パンコムギの節水型耐乾性に寄与するQTLの探索、第15回中国地域育種談話会(鳥取県鳥取市)(2023年9月)	Poster
2023	Domestic	小針大輔、田中裕之: 高温ストレス下のコムギ種子形態を維持する <i>Thinopyrum elongatum</i> 由来Eゲノム染色体の探索と利用、第15回中国地域育種談話会(鳥取県鳥取市)(2023年9月)	Poster
2023	Domestic	辻本壽: ムギ類の研究を楽しもう!、第18回ムギ類研究会(滋賀県大津市)(2023年12月)	Oral
2023	Domestic	岡本昌憲: 多重合成コムギ集団から単離したアブシシン酸高感受性系統の分子遺伝学的解析、共同利用・共同研究拠点 鳥取大学乾燥地研究センター 令和5年度共同研究発表会(鳥取県鳥取市)(2023年12月)	Poster
2023	Domestic	竹田佳生・明石欣也: 植物細胞壁の構造変化による乾燥地植物の高温ストレス耐性機構の解析、共同利用・共同研究拠点 鳥取大学乾燥地研究センター 令和5年度共同研究発表会(鳥取県鳥取市)(2023年12月)	Poster
2023	Domestic	Balla M. Y.: Effect of heat stress on seed mineral contents in multiple derivative lines (MDLs)、共同利用・共同研究拠点 鳥取大学乾燥地研究センター 令和5年度共同研究発表会(鳥取県鳥取市)(2023年12月)	Poster
2024	Domestic	辻本壽: 野生種遺伝子の導入による新規コムギ開発と国際育種への展開、日本農学会第95回日本農学大会(東京都文京区)(2024年4月)	Invited
2024	Domestic	平田駿一郎、山下昂太、梅澤泰史、贅田晃広、辻本壽、妻鹿良亮: 節水型と非節水型コムギ系統におけるリン酸化プロテオームの比較解析、日本育種学会第146回講演会(広島県東広島市)	Poster
2024	Domestic	日名弘貴、石井孝佳、西村和紗、松岡由浩、辻本壽、妻鹿良亮: パンコムギRIL集団を利用した節水型耐乾性に寄与するQTLの探索、日本育種学会第146回講演会(広島県東広島市)(2024年)	Poster
2024	Domestic	辻本壽: 異種遺伝子導入による新規コムギ系統の開発と活用、日本遺伝学会第96回大会(高知県高知市)(2024年9月)	Invited
2024	International	Tsujimoto, H.: Do wild species help to improve the quantitative traits of wheat?, the 3rd International Wheat Congress, Australia (Sep., 2024)	Oral
2024	International	Sakuma, S., Matsumoto, S., Mishina, K., Maruyama, D., Hisano, H. and Nasuda, S.: Mining AE. tauschii genetic diversity for heat stress resilience, seed dormancy and end-use quality, the 3rd International Wheat Congress, Australia (Sep. 2024)	Poster
2024	Domestic	Gorafi, Y. S. A.: Identification of QTLS/genes and mechanism of drought tolerance in wheat synthetic derivatives lines、共同利用・共同研究拠点 鳥取大学乾燥地研究センター 令和6年度共同研究発表会(鳥取県鳥取市)(2024年12月)	Poster
2024	Domestic	Balla, M. Y.: Intraspecific variation for heat stress tolerance in wild emmer-derived durum wheat populations、共同利用・共同研究拠点 鳥取大学乾燥地研究センター 令和6年度共同研究発表会(鳥取県鳥取市)(2024年12月)	Poster
2024	Domestic	Ahmed, M. I. Y.: The intraspecific variation of wheat-related species revealed different mechanisms of climate-resilient tolerance、共同利用・共同研究拠点 鳥取大学乾燥地研究センター 令和6年度共同研究発表会(鳥取県鳥取市)(2024年12月)	Poster
2024	Domestic	小針大輔、西田薫平、田中裕之: <i>Thinopyrum elongatum</i> 由来Eゲノム染色体がもたらす種子関連形質と登熟期間中の高温ストレス耐性、第16回中国地域育種談話会(岡山県瀬戸内市)	Poster
2024	Domestic	辻本壽: 遺伝資源開発による高温・乾燥耐性コムギ育種への挑戦、(公財)農学会・農学アカデミー・日本学術会議育種学分会共同主催公開シンポジウム「気候変動下の食料生産の確保に向けた研究最前線」(東京都文京区)(2025年3月16日)	Invited

### Annex 2-2.3. Award and broadcast

#### (A) Award

Fiscal year	Date	Name of award	Title	Winner	Organizer
2018	2019/1/7	鳥取大学学長賞	乾燥・高温耐性コムギの系統選抜に関する研究が国際的に高い評価	辻本壽	鳥取大学
2019	2020/1/6	鳥取大学学長賞	「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	妻鹿良亮	鳥取大学
2019	2019/12/22	中国地域育種学談話会	最優秀発表賞	松永幸子	岡山大学
2020	2020/12/17	日本学術振興会賞	植物ホルモンのアブシシン酸の作用機構解明と応用	岡本昌憲	日本学術振興会
2020	2021/3/2	鳥取大学科学研究業績表彰	小麦粉品質を高める新規補償コムギ-Thinopyrum elongatum ロバートソン型転座系統	田中裕之	鳥取大学
2020	2020/12/12	中国地域育種学談話会	優秀発表賞	Mohammed	岡山大学
2022	2022/9/11	2nd International Wheat Congress 優秀ポスター賞	Exploiting wild emmer wheat diversity to improve wheat A and B genomes in breeding for heat stress	Mohammed Balla	Crop Science Society of China
2024	2024/4/5	日本農学賞	野生種遺伝子の導入による新規コムギ開発と国際育種への展開	辻本壽	日本農学会
2024	2024/4/5	読売農学賞	野生種遺伝子の導入による新規コムギ開発と国際育種への展開	辻本壽	読売新聞社

#### (B) Broadcast

Fiscal Year	Date	Media	Title	Page
2018	2018/6/21	日本海新聞	乾燥に強いコムギ育種 国際協力事業採択「食料問題解決につなげる」	地域総合 20面
2018	2018/6/28	毎日新聞	「スーダン」鍵に食料問題解決を 鳥大コムギ研究 JST採択	鳥取 26面

2018	2018/7/3	NHK NEWS WEB	乾燥地農業研究が国の事業に採択	
2018	2019/2/7	日経新聞	砂丘の知見世界へ コムギ栽培、課題解決探る	中国経済37面
2018	2018/3/19	読売新聞 夕刊	サハラ潤す・・・砂漠でも1・5倍のコムギ開発	
2019	2019/6/30	AFRICA vol.59	鳥取大学乾燥地研究センターが取り組むアフリカ研	38-39
2019	2019/7/6	NHKBS4K	4Kでよみがえるあの番組 新日本紀行 鳥取県 砂丘農民-鳥取海岸-	
2019	2019/10/4	現代ビジネス	今、砂漠で「農業革命」が起きている。画期的なアイデア6選	<a href="https://headlines.yahoo.co.jp/article?a=20191004-">https://headlines.yahoo.co.jp/article?a=20191004-</a>
2019	2020/1/1	日本海新聞	(特集) 鳥取大、SDGsの取り組み推進	17面
2019	2020/3/13	Top Researchers	小麦の品種改良で、世界の食糧危機を防ぐ～辻本 壽・鳥取大学乾燥地研究センター副所長・教授	<a href="https://top-researchers.com/?p=3646">https://top-researchers.com/?p=3646</a>
2020	2020/8/1	国際開発ジャーナル	スーダンで「奇跡の小麦」を生み出す	28-29
2020	2020/3/16	産経新聞	気候変動に負けない小麦・・・砂丘の研究機関が世	<a href="https://special.sankei.com/f/society/arti">https://special.sankei.com/f/society/arti</a>
2022	2022/9/22	NHK FM1 第一ラジオワールドリポート	スーダンの小麦事情	
2022	2022/11/14	NHK全国 おはよう日本	イタリア 今夏記録的な熱波・干ばつ 小麦の収穫 減少の農家も	<a href="https://www.nhk.or.jp/minplus/0019/topic109.html">https://www.nhk.or.jp/minplus/0019/topic109.html</a>
2022	2022/11/18	NHK鳥取 いろどり	イタリア 今夏記録的な熱波・干ばつ 小麦の収穫 減少の農家も	<a href="https://www.nhk.or.jp/minplus/0019/topic109.html">https://www.nhk.or.jp/minplus/0019/topic109.html</a>
2022	2023/1/29	中海テレビ Road to 2030 ～SDGsで考えるふるさとのミライ～	鳥取発！イノベーション	<a href="https://www.youtube.com/watch?v=iLncATcvG-0">https://www.youtube.com/watch?v=iLncATcvG-0</a>
2022	2023/2/1	NHKEテレ 視点・論点	次の『緑の革命』を目指し	<a href="https://www.nhk.jp/">https://www.nhk.jp/</a>
2023	2023/4/28	NHK国際ニュースナビ 特集 NHK鳥取 いろどり	「スーダンを忘れないで」現地で小麦の研究に携わる男性の願い	<a href="https://www.nhk.or.jp/news/special/international_news_navi/articles/feature/2023/04/28/21248.html">https://www.nhk.or.jp/news/special/international_news_navi/articles/feature/2023/04/28/21248.html</a>

2023	2023/4/28	NHK NEWS WEB WEB特集 NHK鳥取 いろいろ	鳥取大のスーダン人留学生 “衝突早く終結し情勢安定 して”	<a href="https://www3.nhk.or.jp/news/tottori/20230428/4040014901.html">https://www3.nhk.or.jp/news/tottori/20230428/4040014901.html</a>
2023	2023/5/19	NHK NEWS WEB WEB特集	スーダンで“人道危機” 独自 退避の日本人が見たもの	<a href="https://www3.nhk.or.jp/news/html/20230509/k10014060531000.html">https://www3.nhk.or.jp/news/html/20230509/k10014060531000.html</a>
2023	2023/7/5	NHK デジタル総合 1	【特集】スーダン止まらない 武力衝突日本に住むスー ダン出身の研究者の思い キャスター	<a href="https://www.nhk.or.jp/archives/chronicle/detail/?crnid=A202307051005001302100">https://www.nhk.or.jp/archives/chronicle/detail/?crnid=A202307051005001302100</a>
2023	2023/7/13	NHK NEWS WEB WEB特集 NHK鳥取 いろいろ	武力衝突から3か月 日本の スーダン人家族 平和への願 い	<a href="https://www3.nhk.or.jp/news/html/20230713/k10014126351000.html">https://www3.nhk.or.jp/news/html/20230713/k10014126351000.html</a>
2023	2023/12/20	NHK NEWS WEB WEB特集 NHK鳥取 いろいろ	砂丘研究100年記念講演 乾 燥地農業研究の重要性語る 鳥取	<a href="https://www3.nhk.or.jp/news/tottori/20231220/4040016762.html">https://www3.nhk.or.jp/news/tottori/20231220/4040016762.html</a>
2023	2024/3/25	NHK NEWS WEB WEB特集 NHK鳥取 いろいろ	乾燥地の農業振興に尽力 鳥 取大乾燥地研センター長が 最終講義	<a href="https://www3.nhk.or.jp/news/tottori/20240325/4040017403.html">https://www3.nhk.or.jp/news/tottori/20240325/4040017403.html</a>
2023	2024/3/31	読売新聞 朝刊	第61回読売農学賞受賞7人 の業績 高温に強い麦 進 化ヒントに 野生遺伝子の 導入による新規小麦開発と 国際育種への展開	15面
2024	2024/4/9	NHK鳥取 いろいろ	JICAスーダン事務所長 が鳥大乾燥地研究センター	<a href="https://www3.nhk.or.jp/news/tottori/20240409/4040017506.html">https://www3.nhk.or.jp/news/tottori/20240409/4040017506.html</a>
2024	2024/4/15	NHK鳥取 いろいろ	スーダン武力衝突から1年 鳥取在住スーダン人“戦闘 終結を”	<a href="https://www3.nhk.or.jp/news/tottori/20240415/4040017544.html">https://www3.nhk.or.jp/news/tottori/20240415/4040017544.html</a>
2024	2024/4/23	NHK NEWS WEB WEB特集 NHK鳥取 いろいろ	命守る研究続ける “傷つけ 合う”母国スーダンを思う1 年	<a href="https://www3.nhk.or.jp/news/html/20240423/k10014429551000.html">https://www3.nhk.or.jp/news/html/20240423/k10014429551000.html</a>
2024	2024/4/27	NHK デジタル総合 1	戦闘続くスーダン 武力衝突 から1年 避難生活送る人は	<a href="https://www3.nhk.or.jp/news/html/20240427/k10014435301000.html">https://www3.nhk.or.jp/news/html/20240427/k10014435301000.html</a>
2024	2024/5/9	NHKラジオ らじる★ らじる	Nらじセレクト『武力衝突 から1年 鳥取から母国スー ダンを思う農業研究者』	<a href="https://www.nhk.jp/p/nradi/rs/X7R2P2PW5P/episode/re/14V71Q9J93/">https://www.nhk.jp/p/nradi/rs/X7R2P2PW5P/episode/re/14V71Q9J93/</a>
2024	2024/5/14	NHK World News	Sands of Hope: A Sudanese food researcher	<a href="https://www3.nhk.or.jp/nhkworld/en/news/backgroundstories/3305/">https://www3.nhk.or.jp/nhkworld/en/news/backgroundstories/3305/</a>

2024	2024/7/16	鳥取大学プレスリリース	ODA70周年、JICAスーダン事務所開設35周年 鳥取大学とハルツーム大学がオンライン交流	<a href="https://www.tottori-u.ac.jp/news/docs/fa96b23c408226c7894c7f6f0197d0104ae04b76.pdf">https://www.tottori-u.ac.jp/news/docs/fa96b23c408226c7894c7f6f0197d0104ae04b76.pdf</a>
2024	2024/8/8	NHK鳥取 いろいろ	鳥大のスーダン人研究者がエジプトに避難の研究者に成果報告	<a href="https://www3.nhk.or.jp/news/tottori/20240808/4040018370.html">https://www3.nhk.or.jp/news/tottori/20240808/4040018370.html</a>
2024	2024/8/8	日本海新聞	スーダンの大学とオンラインで交流 鳥取大、関係を	23面
2024	2024/12/15	テレビ東京	食の危機を救う！ニッポンの挑戦者たち	<a href="https://www.tv-tokyo.co.jp/informati">https://www.tv-tokyo.co.jp/informati</a>
2024	2025/3/14	NHK	国際報道2025	<a href="https://www.nhk.jp/">https://www.nhk.jp/</a>

**The Final Symposium for Sudan SATREPS Wheat Project:  
Building Resilience through Partnerships**

# **Book of Extended Abstracts**



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**Arid Land Research Center, Tottori University, Japan**

**The Final Symposium for Sudan SATREPS Wheat Project:  
Building Resilience through Partnerships**

# **Book of Extended Abstracts**

Editors:

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Arid Land Research Center, Tottori University, Japan





## 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

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

مشروع تقانات مبتكرة لإنتاج مستدام للقمح (تمام)





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## Foreword

The agricultural sector in Sudan is at a critical crossroads, facing immense challenges due to the current conflict, which has disrupted research, seed systems, and production infrastructure and is further exacerbated by climate change. The JICA- and JST-supported SATREPS Wheat Project, a collaboration between Sudanese and Japanese institutions, has made significant advancements in breeding climate-resilient wheat, better understanding the crop's physiological response to stress, analyzing climate data, and proposing future directions for wheat production, strengthening public-private partnerships, and building local research capacity. Despite setbacks caused by political instability and conflict, the project has successfully identified heat- and drought-tolerant wheat germplasm, improved the availability of quality seed, and developed innovative research approaches to sustain wheat production.

The project has laid the foundation for future agricultural resilience in Sudan through an integrated strategy that combines crop improvement, crop physiology, climate modeling, capacity strengthening, and partnership building. The achievements of the project highlight the urgent need for continued investment in research, seed systems, and policy reforms to ensure food security and sustainable development. Lessons learned could help guide future collaborations and interventions to restore and sustain agriculture in Sudan.

**Prof. Abdelmoneim Taha**

Project Director

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## Preface:

### The Final Symposium for Sudan SATREPS Wheat Project: **Building Resilience through Partnerships**

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Driven by the huge challenges of food insecurity coupled with the ensuing climate change, Agricultural Research Corporation and Tottori University, in collaboration with Sudan Meteorological Authority and Utsunomiya University, developed and implemented the SATREPS Wheat Project in Sudan through generous support from JICA, JST, and Sudan Government. Building on past experiences, the project adopted different models, strategies, and approaches to successfully and efficiently implement its plans and activities. First, the project activities were categorized into five interconnected groups: breeding, quality, physiology, climate change and modeling, and capacity building. Then, the project adopted integrated agricultural research for development and innovation systems approach to overcome the shortcomings of the historically used traditional linear model for research and extension in building strong relationships and interactions among all stakeholders. Securing high-quality seeds is also crucial for producing and delivering essential food crops in the quantities and quality needed. Therefore, recognizing the need for a sustainable strategy to ensure seed production and supply, and building on an earlier seed system analysis, the project established strong public-private partnerships (PPPs) between public and private seed producers.

During the People's Revolution in 2018/19, the security situation delayed the project's kick-off and prevented Japanese experts from visiting Sudan. Then, the COVID-19 pandemic in 2020 and the political turmoil in October 2021 resulted in suspending some project activities, including experts' visits to Sudan, which affected the progress of some project activities. Later, the armed conflict between the paramilitary Rapid Support Force (RSF) and the Sudan Armed Force (SAF), which started in Khartoum in April 2023 and spread to Gezira in December 2023, substantially affected most of the activities, especially the rehabilitation of the molecular and speed breeding facilities and laboratory equipment procurement process. Despite these challenges and difficulties, the project achieved almost all research-based and capacity-building activities. The final symposium of the Sudan SATREPS Wheat Project, "Innovative Technologies for Sustainable Wheat Production: Building Resilience through Partnerships", aims to bring together project members to present the project achievements and milestones and draw lessons and recommendations for future collaboration.

The breeding group evaluated wheat in Sudan and Japan and identified heat- and drought-tolerant lines as well as agronomically important QTLs (Quantitative Trait Loci) and MTAs (Marker-Trait Associations), established a platform for breeding new heat- and drought-tolerant wheat using the identified QTLs, and produced the early-generation seeds of the

heat-tolerant wheat varieties. The quality group studied the end-use quality and nutritional value, selected several potential lines combining heat tolerance and enhanced end-use quality, and identified new QTLs and MTAs that control heat tolerance and enhance end-use quality. The physiology group explored the physiological mechanism of heat and drought tolerance using metabolomics and transcriptomics, identified the key physiological and biochemical factors underlying heat and drought adaptation, and established a new analytical platform to understand crop response to stresses. The climate change group analyzed Sudan's past and future climate and proposed the necessary measures to avoid the risk of climate change, developed a prototype model for wheat production under different climate scenarios, designed an early warning system, and conducted several field studies in collaboration with the breeding group, to develop innovations to mitigate the risk of climate change. The capacity building group conducted a baseline survey in Sudan's major wheat production states and identified key factors influencing the adoption of improved technologies, identified the intervention sites, and established and operationalized six innovation platforms (IPs) for technology validation and dissemination in the main wheat production states. The group conducted short and long-term training in Japan, conducted training workshops and courses for different stakeholders along the wheat value chain, including farmers, extensionists, researchers, technicians, and seed producers in the public and private sectors, produced certified seeds of the popular and recently released wheat cultivars and disseminated to farmers in the IPs sites, provided technical backstopping to the farmers and other stakeholders in the IPs through the production of drama-based episodes, manuals and pamphlets on technological options for wheat production.

The strategies and approaches used by the SATREPS Wheat Project, particularly IPs and PPPs, have raised awareness, contributed to the availability of high-quality seeds, increased technology adoption, and promoted sustainable wheat production. The support of the Ministry of Agriculture, ARC, and other relevant stakeholders and entities will ensure the sustainable dissemination and expansion of improved technologies to new areas.

Given the projected impacts of climate change, particularly heat stress, on agriculture, research on climate-resilient wheat varieties and climate-smart technologies is essential. Investments in localized climate modeling and research on climate change impacts on crop performance are also critical for accurate planning and resilient agricultural systems. Moreover, enabling policies are crucial to ensure food security by providing access to improved technologies, credit, and extension services.

In light of its achievements, and given the importance of post-harvest processes and value addition in maximizing farmers' returns from their own produce and promoting agricultural resilience and sustainability, the project team recommends empowering local rural communities and stimulating their local economic development, integrating gender and youth into such entrepreneurship for better livelihoods of local communities. Establishing entrepreneurial, community-based post-harvest processing facilities is anticipated to reduce farmers' dependence on volatile commodity markets and encourage them to diversify their income sources by adding value to their products through processing, packaging, baking, and possibly branding.

## Group 1: Breeding

### Enhancing the development of climate-resilient and nutrient-use-efficient wheat germplasm through modern breeding technologies

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#### Abstract:

Despite the genetic gains achieved through the development of heat-tolerant wheat varieties and the expansion of wheat cultivation, the substantial increase in consumption due to many factors, including changes in dietary habits, population growth, and urbanization, posed a significant challenge to food security in Sudan. To meet this challenge and bridge the gap between production and consumption in the face of climate change, which is likely to aggravate the situation, it was necessary to adopt innovative approaches and techniques to increase wheat productivity.

Wheat-related wild species have been recognized as an important genetic resource for wheat improvement. Functional qualitative genes found in these wild species, such as disease resistance, have been used in breeding programs. However, there is insufficient evidence that this exotic germplasm can provide useful quantitative traits such as yield performance and abiotic stress tolerance. The morphology of wild species, with tiny seeds in hard and brittle spikelets, is so different from that of cultivated wheat that evaluating the "agronomic traits" of the wild species could be challenging. Therefore, instead of evaluating the wild species themselves, we first developed a highly diverse wheat population by introducing different alleles from many accessions of wild species and then evaluating the agronomic traits of the wild alleles in the wheat genetic background. An important source for improving bread wheat performance and its environmental resilience is to explore the genetic diversity reservoir of inter- and intraspecific variation in *Aegilops tauschii*, the D-subgenome progenitor of bread wheat (Mahjoob et al., 2021a; Mahjoob et al., 2021b; Mahjoob et al., 2022). A total of 43 primary synthetic hexaploid wheat (SHW) lines were developed utilizing 43 *Aegilops tauschii* accessions, covering its intraspecific diversity, crossed and backcrossed with a Japanese commercial cultivar, "Norin 61" (N61), to develop multiple synthetic derivatives (MSD) populations. As such, the MSD population is multigenic with an intraspecific diversity of *Ae. tauschii* in a bread wheat cultivar, N61 (Elbashir et al., 2017), and its use has been proposed to increase the diversity of the D subgenome (Tsujimoto et al., 2015). A total of 400 lines were selected from the MSD population, and each line was genotyped with genome-wide molecular markers to establish an "MSD panel" for genome-wide association studies (GWAS) (Gorafi et al., 2018).

The breeding group evaluated wheat in Sudan and Japan and identified heat- and drought-tolerant lines as well as agronomically important QTLs (Quantitative Trait Loci) and MTAs (Marker-Trait Associations), established a platform for breeding new heat- and drought-tolerant wheat using the identified QTLs, and produced the early-generation seeds of the heat-tolerant wheat varieties.

The MSD lines were evaluated in 16 different agroecological and management environments at Dongola, Hudeiba, and Gezira Research Station Farms, Sudan. At Gezira (Wad Medani), maximum temperatures were above 30°C during most wheat growing periods and sometimes exceeded 35°C, especially during the late grain filling period, whereas Dongola was always 5-8°C cooler than Gezira. At the Gezira Research Farm, the MSD population was evaluated under late sowing conditions to identify lines tolerant to excessive heat stress, under deficit irrigation to evaluate drought stress tolerance, and under low nitrogen and phosphorus conditions to identify lines with efficient nutrient use. Genotypes with improved heat/drought tolerance, resource use efficiency, and heat-tolerant QTLs were identified (Ahmed et al., 2024; Itam et al., 2021, 2022). Nitrogen use efficiency and mineral contents of grain harvested from heat and nutrient deficiency experiments were tested. High genetic variation was found for Mg, P, S, Cu, and Mn in the MSD lines, representing the diversity of 26 *Ae. tauschii* accessions and several MTAs were identified for some essential minerals, which could be useful for improving mineral concentration in heat-stress environments. A novel QTL for seed dormancy was mapped on chromosome 5D using two populations of backcrossed recombinant inbred lines (BILs) developed by crossing and backcrossing two intraspecifically diverse *Ae. tauschii* accessions (Ahmed et al., 2023).

The plant hormone abscisic acid (ABA) plays an important role in drought tolerance and water-saving traits in wheat (Mega et al., 2019). Therefore, lines sensitive to ABA were selected from the MSD population and crossed with N61. Several sensitive lines from the BC1F4 generation were also selected. Under drought stress conditions, these lines reduced transpiration compared to N61 and were identified as water-saving lines during drought. One of these lines showed higher seed productivity and larger seed size than N61. This line is promising for breeding drought-stress tolerant material.

In heat-prone and drylands, such as Sudan, some wheat varieties, including the leading variety, Imam, tend to shatter their grain, resulting in a significant yield loss of up to 30% when the harvesting process is delayed. This underscores the urgent need to develop non-shattering varieties to reduce pre-harvest losses. The mechanism of grain shattering was elucidated, revealing that the horizontally curved awns resulted in the opening of the lemma and palea. Subsequently, a GWAS on a wheat core collection comprising 190 lines revealed significant marker-trait associations in multiple chromosomal regions (Sakuma et al., 2022).

As with bread wheat, diverse populations and lines of durum wheat (*Triticum durum*), including wild tetraploid wheat genome segments, the multiple derivative lines (MDLs), were selected and evaluated in multi-environment trials in Sudan and Japan and found to be a promising source for harnessing the diversity of wild emmer wheat for durum and bread wheat improvement (Balla et al., 2022a). A considerable intraspecific variation among wild emmer wheat accessions was identified in terms of heat stress tolerance (Balla et al., 2025).

The genome-wide association analysis of the diverse set of multiple derivative lines harboring chromosome segments from nine wild emmer wheat parents for agronomic traits under optimum, moderate, and severe heat stress conditions identified promising MTAs, which provides potential genetic materials, alleles, and quantitative trait loci for enhancing wheat adaptation to heat stress (Balla et al., 2022b).

Systematic evaluation of the MSD population under various abiotic stresses, including heat, drought, low N, and low P, revealed a wide phenotypic diversity for all traits studied and led to its registration as a germplasm resource for more systematic and efficient mining of desirable climate-smart traits or genes from *Ae. tauschii* (Gorafi et al., 2025)

Our intensive and systematic phenotypic and genotypic studies have clearly shown that wild species harbor positive alleles for improving stress-tolerant quantitative traits. However, the direct use of such alleles in breeding programs remains challenging unless the additive and epistatic effects of these alleles have been validated. Therefore, molecular markers for stress-adaptive traits are used to generate near-isogenic lines (NILs) using MSD lines with favorable alleles as donor parents and adapted cultivars and other elite cultivars as recurrent parents. These NILs will be used to validate these QTLs, identify causal genes, and develop functional molecular markers for efficient deployment in breeding. Meanwhile, the elite wheat lines with the introgressed QTLs/alleles will be evaluated to assess the value of the wild relatives introduced QTLs/alleles and their suitability for release as commercial cultivars.

## Group 2: Quality

### Enhancing nutritional value and end-use quality of wheat under heat-stressed environments

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#### Abstract:

Wheat grain quality is critical in determining its suitability for food processing and its ultimate nutritional value. The objectives of the research conducted in this group were to identify and analyze genetic resources that perform well without compromising flour quality, particularly in terms of their effectiveness in bread-making, a process that demands dough strength, even under heat-stress conditions. The identified resources could then be used to develop new varieties. For this reason, a genetically diverse population of multiple synthetic derivatives (MSD) was evaluated in multi-environment trials.

The grains of the MSD lines harvested from the experiment conducted under normal conditions at Tottori were used for experiments grown under heat-stress conditions in Sudan. Kernel weight and shape-related traits were evaluated in a panel of MSD lines, together with their genetic background (recurrent parent), Norin 61, grown under normal, heat, and drought conditions. Concurrently, genome-wide association studies were performed. Seed traits (shape, weight, and hardness) of the MSD lines were found to be highly diverse, and the GWAS identified several novel MTAs (Marker-Trait Associations) for seed traits under high-temperature stress (Elhadi et al., 2021a; Elhadi et al., 2021b). To assess the flour quality of the MSD lines grown under heat stress during the grain filling, 145 MSD lines were grown under heat stress conditions in Sudan. The grains harvested from the field experiments in Sudan and Japan were milled, basic flour quality characteristics (protein content, SDS sedimentation volume) were investigated, and the dough strength was calculated. The dough strength of each MSD line was compared with the type of high-molecular-weight glutenin subunits (HMW-GSs), which are the main determinants of dough strength among the seed storage proteins (SSPs) of each MSD line. The results showed that even within the same MSD family, there was a wide diversity in dough strength. The results showed that the MSD lines produced stronger dough with better bread-making properties than the Japanese variety Norin 61, even under heat stress during the ripening period (Mohamed et al., 2022a; Mohamed et al., 2022b). The starch composition of the MSD lines showed a high diversity, with amylose content ranging from significantly higher to lower than that of Norin 61. Wide genetic diversity was found among MSD lines for Cu, Fe, Mg, Mn, P, S, and Zn and several lines with better mineral content were identified (Emam et al., 2025). Several MTAs for some essential minerals were identified, which could be used in breeding for improved mineral concentration under heat stress. These results suggest that MSD lines exhibit various desired flour qualities and can be used for various processing aptitudes.

The MSD lines with excellent basic data on flour quality were grown on a large scale under normal conditions in Tottori, and the grain was milled to flour. Detailed investigation of dough properties showed that the selected MSD lines were weaker in dough than commercial strong flours but could maintain stable dough strength even with longer mixing times. The bread-making test showed that the bread was less puffed than strong flour and that there was room for improvement. Some of the MSD lines could maintain flour quality under heat stress, and the genes and chromosomal regions involved were identified.

The study on the expression of SSPs in well-adapted Sudanese varieties subjected to heat stress during the grain filling period revealed that high expression of SSPs under heat stress contributes to maintaining flour quality (Tanaka et al., 2021). Therefore, some Sudanese cultivars were crossed with Norin 61, which has the *Glu-D1d* gene that makes the 5+10 subunits, one of the HMW-GSs suitable for bread flour. The Sudanese variety Bohaine was used as a recurrent parent for continuous backcrossing, and a line with the *Glu-D1d* gene was bred in the background of Bohaine. The plant material base for understanding how genes and regions affect the bread-making quality and heat tolerance of some Sudanese cultivars has been established.

To search for useful genetic resources from closely related wild species other than *Aegilops tauschii* from which MSD lines are derived, a series of lines with one pair of chromosomes from closely related wild species were subjected to spike culture under heat stress, and the seeds were allowed to ripen. As a result, lines that could maintain seed traits (shape and weight) under heat stress were selected. From the above, it was considered that the selected lines possessed useful genes involved in the maintenance of seed traits under heat stress derived from closely related wild species chromosomes.

## Group 3: Physiology

### Clarification of mechanisms behind heat and water-deficit stress tolerance and better utilization of nutrients toward the development of future breeding strategies

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#### **Abstract:**

Multiple synthetic derivatives (MSD) populations, in which dozens of *Aegilops tauschii* accessions were utilized for D subgenome donor, exhibit high diversity in morphology and agronomic traits. Several genotypes derived from the MSD population show heat stress tolerance and high productivity under high-temperature environments. Elucidating the molecular mechanism underlying the heat stress tolerance will offer new opportunities for developing new breeding markers as well as molecular breeding techniques. Toward these objectives, our research group aimed at understanding the physiological responses of various genotypes under high temperatures in artificial environments. In addition, to understand the molecular mechanism of high-temperature response and its application to breeding, we combined multiple omics methods to search for key metabolites and mRNAs to clarify their molecular mechanism.

In research item 3.1, physiological responses of various wheat genotypes were comparatively analyzed, which revealed that, depending on the growth stage of plants in which high temperature was imposed, it has different effects on their growth characteristics, yield-related traits, and photosynthetic metabolism (Matsunaga et al., 2021a). Under some circumstances in the juvenile phase, heat stress had a positive effect on yield traits. We also established a new experimental system to visualize high-temperature injury and tolerance to photosynthetic metabolism using the temperature response of leaf tissue chlorophyll basal fluorescence ( $F_0$ ), and found inter-genotype differences in the high-temperature adaptation of the photosynthetic system following stress exposure (Matsunaga et al., 2021b). Furthermore, we quantitatively demonstrated that various MSD lines exhibited diverse and characteristic physiological growth responses that differ from those of N61. In collaboration with Group 1, we analyzed soil moisture content and measured chlorophyll content in field plots in Sudan to obtain basic data on wheat physiological responses in the local environment. In addition, we found that when wheat plants in the ripening stage are exposed to high temperatures, the high-temperature tolerance of the next generation of seeds during germination is significantly increased. We found that changes in biomembrane composition and a group of heat shock proteins are involved in acquiring this tolerance.

In research item 3.2, to identify specific metabolites associated with heat stress tolerance, we constructed a database based on comparative analysis of metabolomes of several MSD lines and control wheat lines by LC-MS/MS and ICP-MS. We found that the content of low-

molecular-weight organic compounds and inorganic minerals in the flag leaf varied significantly depending on which growth period the plant was exposed to high temperature (Matsunaga et al., 2021b). In addition, we selected specific molecular marker candidates to characterize high-temperature tolerant and sensitive MSD lines based on multivariate analysis of metabolome behavior combined with physiological behavior and agronomic trait data, which resulted in the identification of  $\beta$ -alanine, serotonin, and putrescine as high-temperature stress molecular markers with positive or negative correlation with agronomic traits, such as harvest index and number of grains per spike. Nitrogen-containing compounds serotonin and putrescine were shown as novel high-temperature stress molecular markers with positive or negative correlations with agronomic traits such as yield. Evaluation of the impact of *Ae. tauschii* D-genome introgressions on the physiological, biochemical, and metabolic plasticity of three wheat multiple synthetic derivative lines (MSDLs) under prolonged drought stress revealed that four metabolites (adenine, gamma-aminobutyric acid, histidine, and putrescine) were specifically and differentially accumulated in the MSDLs, suggesting the differential roles of these metabolites in drought resistance/avoidance (Itam et al., 2020a; Itam et al., 2020b)

To analyze the behavior of high molecular compounds in the plants, which are difficult to analyze with LC-MS or ICP-MS, we have introduced Fourier Transform Infrared Spectroscopy (FTIR), an excellent tool for analyzing groups of macromolecule compounds. We developed a new technique to analyze changes in macromolecule composition under high-temperature stress in wheat leaves through chemometrics of spectral data and machine learning. Using this approach, we detected infrared spectral responses characteristic in high-temperature tolerant lines, in addition to spectral responses common in many wheat lines (Osman et al., 2022a; Osman et al., 2022b). We developed spectral markers based on these responses. This method was applied not only to wheat plants in an artificial growth chamber but also to leaves of wheat lines grown in Wad Medani, Sudan, which showed differential metabolome response under field conditions. These analyses showed that the metabolome responses of the lines changed significantly in response to genotypic differences and environmental conditions, providing fundamental data for elucidating the similarities and differences in the molecular responses of wheat plants in the field and in the artificial climate environment.

The FTIR monitoring technique of chemical structures established in this study was applied to the research on flour quality in Group 2 research activities. Consequently, wheat flour of N61 derivative introduced with the Glu-D1d gene, which has excellent bread-making properties, was shown to be discriminated from control N61 flour by FTIR. FTIR technique has the advantage of simple and rapid measurement, and this is an example of the synergistic effect of inter-group collaborations in this project.

Gas chromatography analysis revealed that the monosaccharide composition of the cell wall pectin fraction changed in response to high-temperature stress. This observation suggested that the cell wall of wheat leaves undergoes a massive structural change in response to high-temperature stress. This finding is interesting because it suggests the possibility of a novel tolerance mechanism that regulates the efficiency of heat dissipation from the leaves under high-temperature stress.

In research item 3.3, transcriptome comparison was conducted using six MSD lines with different high-temperature tolerances and a control N61 line in a growth chamber environment. In this analysis, heat stress was imposed for seven days after anthesis, and the RNAseq data comprising approximately 1.2 billion reads were obtained from the plants' flag leaves under high temperature or control conditions. The results showed that a considerably high fraction of the detected gene transcripts was significantly up- or down-regulated under high temperatures, which included the genes showing different expression behavior between the lines. The observations suggested that differentially regulated genes may be associated with unique high-temperature responses in the MSD lines.

Gene ontology and pathway analyses of these heat-responsive genes indicated that they are involved in a variety of cellular processes, including protein metabolism (biosynthesis, transport, repair, and degradation), defense against oxidative stress, cell repair, signal transduction, primary metabolism, and plant-specific metabolism. Some of the high-temperature-responsive genes were explicitly detected in high-temperature-tolerant MSD lines, which may be related to the agronomic traits of the MSD lines as described above, suggesting that these transcripts can be the promising mRNA markers for selecting high-tolerant lines. We are currently mining these data for further details to elucidate the mechanism of high-temperature stress tolerance and develop molecular markers that will contribute to molecular breeding.

## Group 4: Climate Change

### Climate-wheat interaction in hot and dry environments of Sudan

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#### Abstract:

Sudan, characterized by its diverse climatic zones and increasing vulnerability to climate change, faces significant challenges in sustaining agricultural productivity, particularly in wheat cultivation. As one of the primary staples, wheat is crucial for food security and livelihoods in the region. However, rising temperatures threaten the viability of wheat production. The climate change group synthesizes recent studies and research findings on the interplay between climate variables and wheat yield, emphasizing canopy temperature management, cultivar selection, and innovative agricultural practices. By understanding the relationship between temperature and yield, alongside developing adaptive strategies, stakeholders can work towards enhancing wheat productivity and resilience amid changing climatic conditions.

#### 1. Yield-temperature relationship

##### 1.1 Past

Musa et al. (2021) investigated the relationship between irrigated wheat yields and temperature over 48 crop seasons across Sudan's major wheat-producing regions and highlighted the following.

- Temperature trends: The study identifies significant upward trends in both annual and growing-season maximum and minimum temperatures across all regions. Notably, Dongola in the Northern State experiences the most pronounced increases.
- Yield trends: Irrigated wheat yields showed a positive trend across all three regions owing to technological development such as improved cultivars, increased fertilizer application, and better irrigation, but this trend was not uniform and experienced interruptions in some years.
- Impact of temperatures on yield: Detrended yield analysis revealed significant negative correlations between yields and several temperature indicators, especially minimum temperatures at night and maximum temperatures during key growth stages (e.g., flowering, ripening). The strength of this relationship varied across regions. For instance, in the Northern State, nighttime minimum temperatures had the strongest negative correlation. In Gezira State, maximum daily temperatures had the most influence. In Kassala State, both daytime and nighttime temperatures were negatively correlated.

##### 1.2 Future

Iizumi et al. (2021) emphasized the following points about the future challenges faced by wheat supply in Sudan due to climate change and rising demand.

- Projected trends: The research indicates that Sudan's wheat-growing regions, already among the hottest globally, will witness a reduction in domestic production share from 16% to as low as 4.5–12.2% by 2050, depending on climate scenarios.
- Demand versus Supply dilemma: With wheat demand projected to triple by 2050, significant annual yield improvements of 0.2-2.7% are required to meet future demand, particularly challenging for hotter regions.
- Adoption of adaptation strategies: The study highlights the need for immediate adaptive strategies, emphasizing that breeding heat-tolerant varieties and optimizing sowing dates could mitigate some adverse effects.

## 2. Canopy temperature

### 2.1. Observations

[Mohammed et al. \(2023a\)](#) and [Mohammed et al. \(2023b\)](#) signified key contributions to optimizing wheat cultivation in the hot, arid regions of Sudan by focusing on micrometeorological characteristics and energy balance in wheat fields.

- Enhanced crop management practices: Both studies emphasize the necessity of targeted agricultural practices tailored to local environmental conditions. More specifically, they highlight that effective management strategies must consider the interplay between crop physiology, irrigation techniques, and local climate conditions. This is paramount in regions experiencing extreme temperature fluctuations, where conventional farming practices may not suffice.
- Selection of heat-tolerant cultivars: The detailed examination of two heat-tolerant wheat cultivars, Imam and Bohaine, demonstrates the substantial impact of cultivar selection on managing crop temperatures during periods of heat stress. The findings indicate that Imam's ability to maintain cooler canopy temperatures due to its larger leaf area and higher transpiration rates provides a practical blueprint for breeders and farmers aiming to mitigate the impacts of elevated ambient temperatures.
- Insights into micrometeorological processes: The studies underscore the significance of energy balance in crop fields, particularly where latent heat flux (LE) exceeds sensible heat flux (H). This indicates that irrigation should not merely serve as a water supply but is a vital tool for temperature regulation in wheat fields. Effective irrigation practices that prioritize cooling can minimize heat stress and enhance crop resilience.

### 2.2 Model simulation

[Izumi et al. \(2022\)](#) investigated using crop canopy temperature ( $T_c$ ) versus air temperature ( $T_a$ ) to develop high-temperature indicators for agrometeorological services.

- $T_c$  versus  $T_a$ : The study finds that using  $T_c$  as a high-temperature indicator significantly improves the prediction of yield reductions caused by heat stress compared to  $T_a$ . The analysis, based on data from three Sudanese regions over five decades, reveals that  $T_c$ -based indicators are particularly effective during critical phenological periods—specifically vegetative and reproductive growth stages.
- Regional specificity: The data clearly show that while  $T_c$  indicators generally perform better, the optimal indicators vary by region, highlighting the necessity for localized assessments. This supports the call for agrometeorological services to adopt  $T_c$ -based indicators for more precise and applicable heat stress assessments across different regions.

### 3. Yield outlook

#### 3.1 Downscaling

Musa et al. (2022) evaluated various cumulus convection schemes within the Weather Research and Forecasting (WRF) model to enhance the simulation of Sudan's climate, particularly during crop-growing seasons.

- Performance of parameterization schemes: The evaluation identifies the Betts-Miller-Janjic (BMJ) scheme as the best performer for modeling wet-season rainfall in hyper-arid and arid zones, while the improved Kain-Fritsch (KFT) scheme excels in the semi-arid zone. For dry-season temperatures (November-February), both BMJ and modified Tiedtke (TDK) schemes demonstrate superior performance for maximum temperatures, whereas the Grell-Freitas (GF) scheme is most effective for minimum temperatures.
- Seasonal variation in modeling: The results reveal that no single parameterization scheme universally outperforms others across all conditions, emphasizing the need for seasonal and climatic zone-specific applications. The validation against satellite-based data demonstrates the model's capacity for accurately simulating key climate variables, underscoring its utility for future agricultural planning.

#### 3.2 Yield forecast

Musa (2022) investigated the feasibility of forecasting wheat yield anomalies in Sudan using statistical models based solely on temperature data. The analysis incorporates historical wheat yield data alongside temperature indicators from three regions (Northern, Central, and Eastern). A backward stepwise multiple linear regression model is crafted to assess the impact of various temperature metrics on yield anomalies.

- Model performance across regions: The findings reveal variability in model performance; in the Northern region, a two-variable model explains 27% of yield variance with moderate accuracy (0.50 for observed data); the Central region's single-variable model exhibits lower explanatory power (17% variance), reflecting the model's limited effectiveness; and the Eastern region benefits from a more robust two-variable model, accounting for 41% of the variance and demonstrating remarkable forecast accuracy (0.86 for forecasted data).
- Implications for yield prediction: These results indicate that while statistical models can effectively predict yield anomalies, their accuracy is influenced by the number of significant predictors and the extent to which temperature alone captures the variability inherent in yield data. Recommendations for incorporating additional factors, like irrigation practices, could enhance model precision.

### 4. Conclusions

The cumulative findings from the above studies underline the critical need for strategic interventions in wheat production systems in Sudan. As climate change intensifies its impact on agricultural practices, it has become increasingly evident that adaptable, evidence-based approaches are essential for ensuring food security and agricultural resilience.

- Rising temperatures and heat stress: Significant upward trends in temperature and their adverse effects on wheat yields have been consistently identified. The historical correlation between temperature indicators and yield anomalies highlights the urgency of addressing these environmental challenges.

- Importance of heat-tolerant cultivars: The investigations stress the importance of optimizing cultivar selection and management practices to enhance crop resilience against heat stress, supporting the development of new wheat varieties that withstand extreme climatic conditions.
- Adaptation strategies are essential: Research indicates that without proactive adaptation strategies, including improved irrigation management, breeding programs, and optimized sowing schedules, future wheat production in Sudan could face severe challenges.
- Precision in climate modeling: Effective climate adaptation necessitates accurate climate modeling; thus, adopting region-specific parameterization schemes and integrating canopy temperature indicators in assessments are recommended for precise agricultural planning.

## 5. Recommendations

Based on the findings of the climate analysis, the following are recommended to the stakeholders.

- Invest in heat-tolerant wheat varieties: Agricultural research should prioritize the development of wheat cultivars that exhibit heat tolerance traits, enhancing their performance under stress conditions projected for the future.
- Optimize irrigation techniques: Implement innovative and strategic irrigation practices that maximize cooling effects in wheat fields, thereby reducing temperature stress and improving crop yields during hot months.
- Utilize canopy temperature as an indicator: Encourage the adoption of canopy temperature ( $T_c$ ) as a primary indicator in agrometeorological services to enhance predictions regarding heat stress impacts on yield in various Sudanese regions.
- Enhance climate modeling practices: Foster investments in localized climate modeling efforts that utilize appropriate parameterization schemes to accurately forecast rainfall and temperature inputs essential for wheat cultivation planning.
- Promote adaptive agricultural practices: Provide training and resources to farmers on adaptive practices such as adjusted sowing dates, diverse crop rotations, and integrated pest management, all tailored to respond to climate variability.
- Strengthen R&D initiatives: Increase funding for agricultural research focused on understanding the impacts of climate change on crop performance, which will pave the way for resilient agricultural systems in the face of evolving environmental challenges.
- Support policy development for food security: Advocate for comprehensive agricultural policies that promote food security initiatives, including technology access for farmers, research funding, and infrastructure improvements.

## Group 5: Capacity Building

### Building strategic partnerships and establishing and operationalizing innovation platforms

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#### Abstract:

Increased technology adoption can contribute to economic growth and poverty reduction among farmers, provided that successful strategies to address constraints to technology adoption are identified and solutions are implemented (Ibrahim et al., 2024). Before implementing the project activities in Sudan, a study was conducted to assess the level of adoption of improved technologies and management practices and to identify the key factors influencing their adoption in the major wheat-producing areas of Sudan. Access to quality seeds, financial credit, and extension services were the most critical determinants of farmers' adoption of the improved technologies (Ibrahim et al., 2024).

Traditionally, the transfer of new technologies, including new varieties, to farmers has followed the traditional linear model of research and extension. This linear model lacks the necessary interaction and feedback learning among stakeholders along the crop value chain. The integrated agricultural research for development and innovation system approach was introduced to overcome this shortcoming and build strong relationships and interactions among all stakeholders. Following this approach, the project established six innovation platforms (IPs) in four major wheat-producing areas in Sudan: Gezira (2 IPs), New Halfa (2 IPs), River Nile (1 IP), and Northern State (1 IP). The IPs allowed different stakeholders in the public and private sectors, including policymakers, to interact to understand each other better, learn and develop shared priorities, identify challenges, create opportunities and solutions, define roles, and agree on joint actions and work plans to realize agricultural revitalization and development (Tahir et al., 2020). A series of activities were carried out within the IPs, including technology dissemination and scaling up, technical backstopping, capacity strengthening, seed production and distribution, field and harvest days, etc.

The availability of high-quality seeds is critical to the sustainable production and supply of essential food crops in the required quantity and quality. Seeds are the foundation of any good agricultural practice that seeks to provide food security for an ever-growing population in the face of climate change. To ensure continued, economically viable seed production and supply, a sustainable and balanced strategy is needed. Building on an earlier comprehensive analysis of the seed system, the project established strong public-private partnerships (PPPs) between public and private seed producers.

Plans were made to produce breeder, pre-basic, and basic seeds of all commercial, heat-tolerant bread and durum wheat varieties and provide them to the public and private seed producers for certified seed production. These strong PPPs enabled the production of certified seeds of heat-tolerant wheat varieties and their dissemination to farmers at the IP sites and

beyond. The quantity of seed produced through the project in partnership with the public and private sectors increased from 41.7 tons in the first season (2020) to 5,411 tons in the third season (2022) and to more than 13,600 tons in the fourth season (2023). These amounts represented only 0.12% of the total national seed production in the first season; however, the percentage increased to 1.5, 18.7, and 34% in the second, third, and fourth seasons, respectively (Tahir et al., 2023, 2024). Even under the extremely insecure conditions in 2024, the project, with its partners, produced more than 10,000 tons of seed for the commercial and recently released varieties. It is important to emphasize that the ongoing conflict threatened the availability of seeds for the current wheat season (2024/25). Nevertheless, the project was able to directly or indirectly contribute about 50% of the available seed for the current season.

A direct comparison between participating farmers (PF) in project activities and non-participating farmers (NPF) in 2021/22 showed a 33% increase in the productivity of PF compared to NPF, mainly due to the use of high-quality seeds (Tahir et al., 2023). In 2023/24, another direct comparison between the PF and NPF in the project activities showed a 44.6% increase in productivity of PF compared to NPF. For instance, feedback from farmers at the annual review and planting meetings and the field days in one of the IPs showed a considerable increase in areas and productivity of wheat at the IP sites. Coupled with the capacity strengthening of the farmers and all other stakeholders along the wheat value chain, the increased productivity has increased the motivation of IP stakeholders and those outside the IPs to adopt improved technologies and further increased the demand for high-quality seeds.

Long-term training for seven graduate students (PhD) and short-term training for five researchers were conducted in Japan. Training and technical backstopping to the farmers and other stakeholders in the IPs were provided through training workshops, farmers' field schools, technology validation and dissemination plots, technical symposia, field and harvest days, and several TV and radio training programs, as well as the publication of booklets, manuals, and pamphlets on technological options for wheat production. A total of 498 participants attended 15 training workshops and courses. Over 1350 people participated in 18 field and harvest days at various IP sites. Moreover, five innovative drama-based episodes were produced and broadcasted via different media, including YouTube, TV, public transportation buses and trains, WhatsApp, Facebook, Twitter, etc. These episodes have received over 19,275 views on the YouTube channel alone (<https://www.youtube.com/@satrepwheatprojectsudan-5600/videos>). More than 2,560 farmers, researchers, agricultural engineers, technicians, extension workers, seed producers, input suppliers, etc., have directly or indirectly benefited from the project's activities at various IP sites.

The establishment and adoption of the PPPs inspired strong interactions among stakeholders and resulted in the production of over 90% of the seed produced by the project, compared to only about 6% produced directly by the project fund. Our experience in efficient seed production through strong PPPs could be shared with countries with weak seed systems in Sub-Saharan Africa.

The innovation platform approach and the strong PPPs adopted by the project are expected to ensure the sustainability of technology dissemination and upscaling to new areas, with support from the ARC and the technology transfer bodies at the Ministry of Agriculture.

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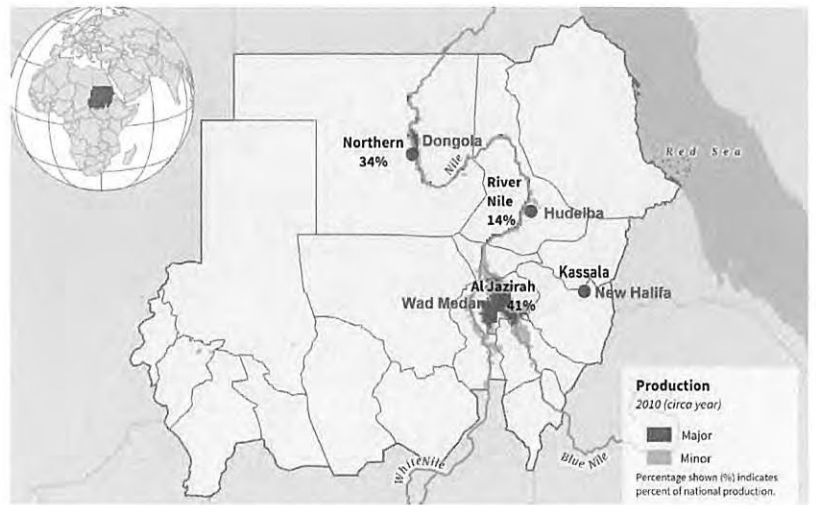


## Photo Gallery

# Photo gallery



Logo of Sudan SATREPS Wheat Project



Sites of the project research and other activities in Sudan

## Meetings



The project kick-off meeting held at ALRC, Tottori University, due to security situation in Sudan (August 2019)



First Joint Coordination Committee (1st JCC) Meeting held at ARC, Khartoum, Sudan (February 2020)



3rd JCC Meeting held online due to COVID-19 pandemic (October 2021)



6th JCC Meeting, held in hybrid in Tottori and Cairo, Egypt, due to armed conflict in Sudan (August 2024)

## Field activities



Heat and drought stress tolerance trials at Gezira Research Station Farm (ARC, Wad Medani).



Elite wheat germplasm trials shared with a number of African countries



Mobile weather station for microclimate monitoring in wheat fields



Major field activities of SATREPS Wheat Project (2019/2020)



Crossing block for new germplasm development

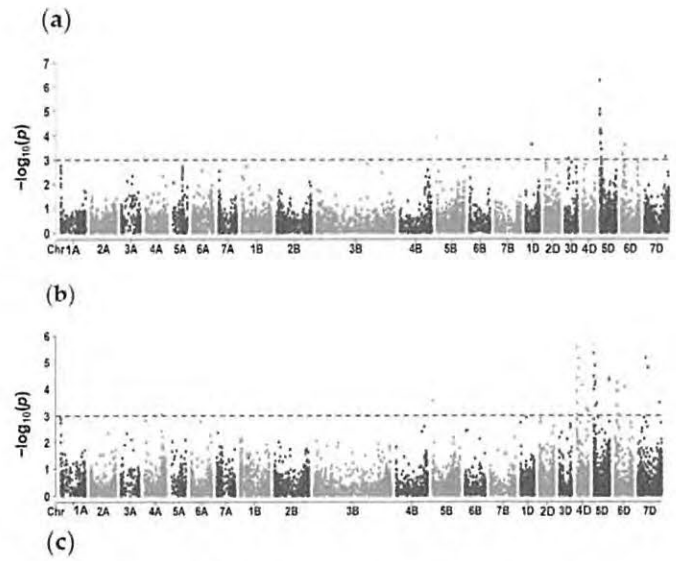


Basic seed production of heat-tolerant wheat varieties

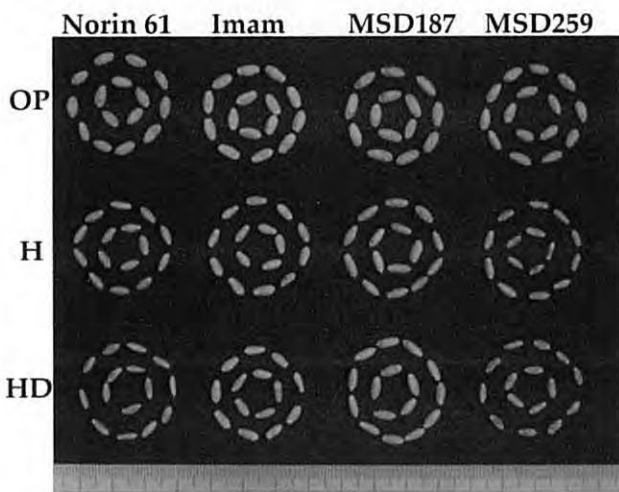
## Laboratory activities



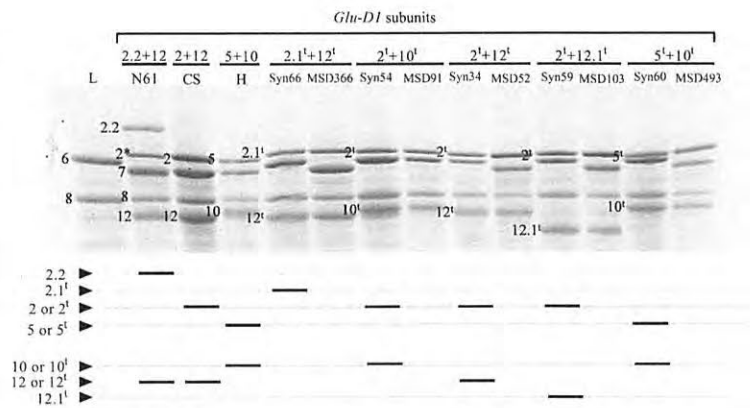
Testing the effects of high temperature on plant and seed morphology



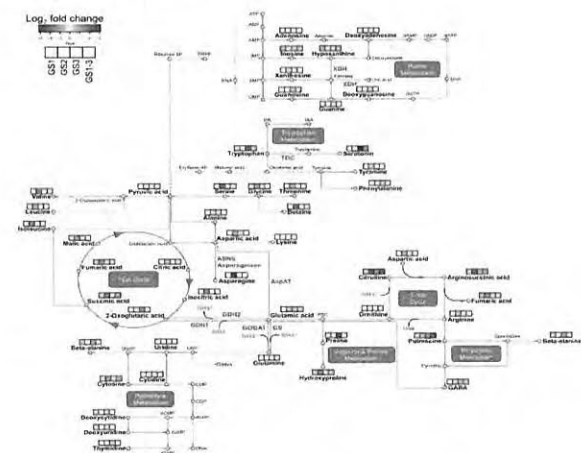
Manhattan plot to elucidate genomic region associated with phenotypic traits



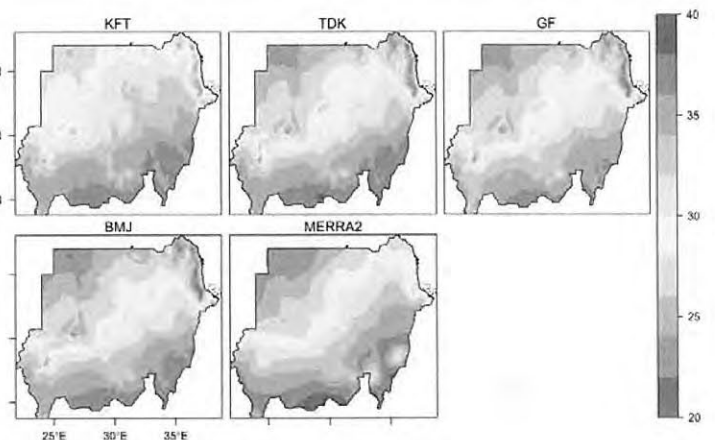
Genetic variation for heat tolerance in seed morphology



Polyacrylamide gel electrophoresis for detecting HMW-glutenin subunits essential for grain quality



Identification of specific metabolites involved in high-temperature tolerance in wheat



Simulated spatial distributions of the 10-year seasonal rainfall (mm) and seasonal maximum and minimum temperatures (°C).

## Capacity building



Doctor course entrance ceremony of four students (October 2019)



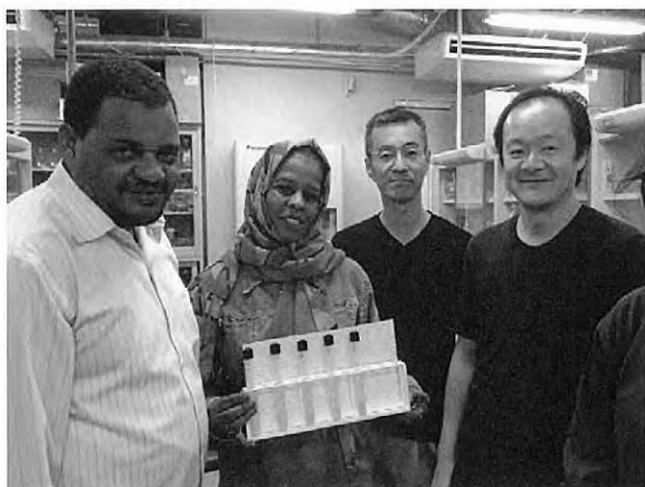
Doctor's degree awarding ceremony of three trainees (September 2022)



Two trainees arrived late due to the COVID-19 pandemic (July 2021)



Doctor's degree awarding ceremony of two trainees (March 2024)



Short-term trainees in advanced molecular and biochemical analytical methods (September 2019)



Short term trainees in advanced breeding and physiological analytical methods (August 2022)

# Innovation Platform activities

**Agricultural Research Corporation - Wheat Research Program**  
**SATREPS Wheat Project**  
**In Collaboration with**  
**Amtaar Investment Company L.L.C**

Training Course on:  
**Innovation Platforms for Sustainable Wheat Production**

North State - Ad-Dabbah Locality 9 - 11 March 2021

**هيئة البحوث الزراعية - برنامج بحوث القمح**  
**مشروع تقانات مبتكرة لإنتاج مستدام للقمح (تعام)**  
**بالتعاون مع**  
**شركة أمطار للاستثمار الزراعي**  
**دورة تدريبية:**  
**منصات الابتكار من أجل إنتاج مستدام لمحصول القمح**

الولاية الشمالية - محلية الدبة 9 - 11 مارس 2021



Training course for extension facilitators and seed production technicians in partnership with the private sector



Communicating with farmers at an IP site (left) and at a field day (right), to encourage adoption of innovative wheat production technologies.



Technical training for farmers on field machineries


Seed production at IP site in partnership with private seed producers

# Materials for dissemination of innovative wheat production technologies

JICA-JST SATREPS Project

**Innovative Technologies for Sustainable Wheat Production in Sub-Saharan Africa (Tamam)**

تقانات مبتكرة لإنتاج مستدام للقمح (تامام)



**Mission**

Contribute to food security in Sub-Saharan Africa by developing heat resilient wheat cultivars and technologies

2019-2024

Project website:  
<https://sites.google.com/tottori-u.ac.jp/wheat-satreps-sudan-japan/home>

**For Farmers**



**Short Episodes for Wheat Production Technologies**

سلسلة الفيديوهات الإرشادية



هيئة البحوث الزراعية  
 برنامج بحوث القمح بالتعاون مع جامعة توتوري في اليابان

مشروع  
 تقانات مبتكرة لإنتاج مستدام للقمح (تامام)

**الخيارات التقنية لإنتاج مستدام للقمح في السودان**

Drama-based short episodes for dissemination of wheat production technologies

Booklet on “Technical Options for Sustainable Wheat Production in Sudan”, 1<sup>st</sup> edition, 34 pages



Field days organized at wheat seed production sites



Farmer-managed demonstration plots for technology validation and dissemination

## Major equipment provided in the project



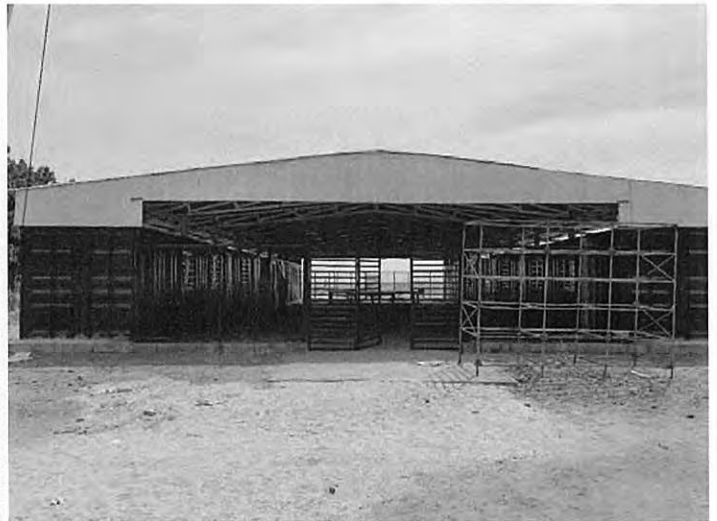
Precise plot drill for research purpose



Plot combine harvester for breeding and seed production



Weather station for monitoring microclimate in wheat field



Container workshops for and experiment preparation and measurements



Exterior view of the proposed molecular breeding facility



Molecular and speed breeding facility halted by the armed conflict



### About the Project

- **Title:** 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.
- **Duration:** April 2019 – March 2025 (JST Project) and November 2019 - March 2025 (JICA Project).
- **Objectives:** 1- Improve the productivity and nutritional value and accelerate the process of wheat improvement to adapt to climate change by applying modern technologies and identifying the mechanisms that lead to adaptation of wheat to abiotic stresses, 2- Develop alternative scenarios and models for wheat production in Sudan that are appropriate for future climate changes and use them to determine priorities and develop strategies to improve wheat production and provide information for future wheat breeding strategies, 3- Develop and disseminate agricultural technologies and innovations, strengthen research facilities and enhance the capacity of all stakeholders along the wheat value chain, and avail high quality seeds of heat-tolerant wheat varieties.
- **Implementing Agency:** Sudan: Agricultural Research Corporation (ARC) and Sudan Meteorological Authority (SMA). Japan: Tottori University (TU) and Utsunomiya University (UU).
- **Funding agency:** Japan International Cooperation Agency (JICA), Japan Science and Technology Agency (JST), and Government of Sudan (local component).

Annex 2-2.5. Workshop and outreach

Fiscal Year	Date	Name	Place	Number of participants (No. of Sudanese)	Open/ Closed	Contents
2019	2020/3/6	TAAT Wheat compact Sudan irrigated wheat seed production and technology scaling up traveling workshop	Gezira State, Sudan	(ca. 100)	Open	The workshop was led by ARC, the project's counterpart agency. Progress and effectiveness of irrigated agriculture in Gezira Scheme were reviewed. Exchanged views on wheat cultivation.
2019	2020/3/9-12	Wheat harvesting technologies and reducing harvest loss workshop	Gezira State, Sudan	(ca. 50)	Open	The workshop was led by ARC, the project's counterpart agency. The workshop aimed to improve harvesting techniques to avoid harvest losses. Personnel in charge of the project participated from all over the country. Participated in the opening ceremony and
2019	2020/8/3	みどり「適塾」第9回デザイン思考勉強会	大阪大学産業科学研究所（日本）	30	Open	「アフリカ固有植物群の遺伝資源の探索」のテーマで、スーダンサトレップス事業を紹介
2020	2021/2/25-3/14	乾燥地研究センター設立30周年記念パネル展「鳥取砂丘から世界の乾燥地研究へ」	鳥取砂丘ビジターセンター	不明（非常に多いと思われる）	Open	SATREPSの解説とともに開発のコムギ標本を展示した。
2021	2021/12/11	近畿作物育種研究会公開シンポジウム「気候変動への対応を目指した作物生産」	オンライン	不明（非常に多いと思われる）	Open	招待を受け、SATREPSの成果を発表した。
2021	2022/1/22	気候変動についてみんなで考えよう	栃木県那須塩原市(日本)	19名	Open	気候変動が農作物に与える影響と対応策の市民向けワークショップ
2022	2023/1/12	Organic Fertilizer Preparation and application	Gezira State, Sudan	(57)	Open	ARC, the project's counterpart agency, took the lead in conducting the workshop.
2022	2023/1/18	Organic Fertilizer Preparation and application	ゲジラ州 Northern State	(25)	Open	ARC, the project's counterpart agency, took the lead in conducting the workshop.
2023	2023/10/27	東京理科大学 生物環境イノベーション研究部門・公開シンポジウム「コムギにおけるアブシシン酸受容体を介した乾燥ストレス応答と病害応答の分子機構」	東京都葛飾区（日本）	約100名	Open	招待を受け、SATREPSおよびコムギの耐乾性に関する研究成果を発表した。
2023	2023/12/4	植物科学シンポジウム「乾燥と病気に強いコムギの開発」	東京都文京区（日本）	オンサイトとオンラインのハイブリッド不明（非常に多いと思われる）	Open	招待を受け、SATREPSおよびコムギの耐乾性に関する研究成果を発表した。
2023	2023/12/10-14	WFP Cooperation Field Machinery Operator Training “Mechanization of Wheat Production Operations in Sudan”	Gezira State, Sudan	(25)	Open	In cooperation with the WFP, a training course was held for on-site machine operators.
2024	2024/8/7	ODA70周年、JICAスーダン事務所開設35周年 鳥取大学とハルツーム大学がオンライン交流	エジプトカイロ市/鳥取大学乾燥地研究センター	ハイブリッド（エジプトおよび日本約30名、オンライン約15名）	Open	鳥取大学とスーダンの学術交流、および、SATREPSおよびコムギの耐乾性に関する研究成果を発表した。
2024	2025/2/13	SATREPS Wheat Project: Innovative Technologies for Sustainable Wheat Production: Building Resilience through Partnerships	Arid Land Research Center	ca20 (ca20)	Open	The final research results of SATREPS were presented in a symposium style.

**Annex 3-1 Joint Coordination Committee Meeting**

Fiscal Year	Date	Name of meeting	No. of participants	Place	Agenda
2019	2020/3/1	1st JCC Meeting	18	Shambat, Sudan	Review of project progress, sharing of input results, and discussion of some revisions of PDM and PO.
2020	2020/12/2	2nd JCC Meeting	14	online	Review of project progress, sharing of input results, and discussion of some revisions of PDM and PO.
2021	2021/10/20	3rd JCC Meeting	32	online	Review of project progress, sharing of input results, and discussion of some revisions of PDM and PO.
2022	2022/10/26	4th JCC Meeting	29	online	Review of project progress, sharing of input results, and discussion of some revisions of PDM and PO.
2023	2023/11/1	5th JCC Meeting	25	online	Review of project progress, sharing of input results, and discussion of some revisions of PDM and PO.
2024	2024/8/6	6th JCC Meeting	25	Cairo, Egypt	Review of project progress, sharing of input results, and discussion of some revisions of PDM and PO.

**Annex 3-2.1. Project Design Matrix version 1**

**Project Title:** Project for 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

**Implementing Agency:** Agricultural Research Corporation (ARC), Sudan Metrological Authority (SMA)

**Target Group:** Researchers and Technicians of ARC, SMA and farmers

**Period of Project:** 5 years

**Project Site:** Wad Medani

**Experimental Site:** Hudeiba, Dongola, New Halfa

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumption
<b>Overall Goal</b> Climate change resilient and nutritious candidate wheat varieties are newly developed by ARC	At least two (2) new candidate varieties are developed	Annual Report of ARC Ex-Post Evaluation of the Project	
<b>Project Purpose</b> Climate change resilient and nutritious wheat germplasm and the appropriate wheat production method are developed, and that information is shared with the people concerned with the wheat production	1. The seminar on the results of the Project is organized 2. At least three (3) reports related to the Project are published by the international journals	1. The proceeding of the seminar on the results of the Project 2. The Project completion report 3. International journals	ARC secures enough budget even after the end of the project and continues to develop new wheat varieties using the wheat germplasm identified by the Project
<b>Outputs</b>			
1. Heat, water deficit tolerant and nutrient-use efficient wheat lines are developed using modern technologies	Ten (10) elite wheat lines with enhanced tolerance to heat and water deficit stress with better nutritional value and more efficient in resource utilization are made available	The publications and project reports	Something uncontrollable that would delay the activities of the Project will not happen
2. Nutritional value and end use quality of wheat are enhanced under the heat-stressed environments of Sudan	Germplasm with enhanced nutritional value is identified	1. The publication and Project reports 2. The Project impacts assessment survey	
3. Mechanisms behind heat and water-deficit stress tolerance, and better utilization of nutrients are clarified and information is made available to be utilized in future breeding strategies	3.1. At least two (2) mechanisms behind heat and water-deficit stress tolerance, and better utilization of nutrients are clarified and information are made available 3.2. Data-server for the analysis of at least ten (10) sets of omics data are made available	1. The publications and project reports	
4.1. Wheat production scenarios in Sudan for future climate change are developed 4.2. Sustainable, environmentally friendly and appropriate wheat production technologies are developed	4.1. Alternative scenarios and models for wheat production are made available 4.2. Two wheat production technologies are developed	1. The publications and project reports 2. The project reports and the Proceedings of the National Husbandry committee of the Sudan Ministry of Agriculture	
5. Capacity of researchers and farmers are strengthened and interaction among different stakeholders are enhanced for increased and sustainable wheat production	(Innovation Platform (IPs)) * 5.1. Five (5) IPs are established 5.2. Five hundred (500) farmers in total are directly involved in IP activities 5.3. Productivity of directly participating farmers increases by 20% 5.4. Fifteen thousands (15,000) people view the contents of the web site and the multimedia provided by the Project (Capacity Development) 5.5. Ten (10) MSc or PhD degrees are obtained	1. The project reports	
<b>Activities</b>	<b>Inputs</b>		<b>Important Assumption</b>
	<b>The Japanese side</b>	<b>The Sudanese side</b>	
1.1. Multilocation evaluation for selection and confirmation of the desired lines 1.2. Development of RILs for each of the desired traits, genotyping and QTLs identification 1.3. Development of PCR markers for the identified QTLs 1.4. QTLs pyramiding in the background of N61 and Sudanese cultivar 1.5. Initiate and establish MAS to transfer the desired QTLs to Sudanese wheat genetic background 1.6. New lines registration 1.7. Establish future breeding strategies based on climate analysis output 1.8. Selection of ABA hyper-sensitive line for drought tolerance and QTL analysis	1. Allocation of the Japanese experts 2. Machinery and Vehicle procurement and maintenance 3. Establish molecular and speed breeding facility 4. Equipment's for molecular and speed breeding 5. Twenty-Five (25) Short and medium-term specialized trainings in Japan and Sudan for Project counterparts and other IP stakeholders 6. Local cost for the activities for the different activities of the Project	1. Allocation of the counterpart personnel 2. Provision of offices and necessary space for the Japanese experts 3. Local cost (salary of the personnel, utilization of existing machinery and equipment, maintenance and running cost of the machinery) 4. Provision of postgraduate degree assistantship in local universities 5. Provision of experimental farms and laboratory space at all sites	• Electricity, Water, Basic Infrastructure, Materials necessary for the experiments (regents, chemicals, samples in the processing of mRNA to cDNA in the molecular genetics study) are available
2.1. Examine the seed characters and quality parameters of lines grown under heat and stress conditions 2.2. Analysis of protein content and bread making quality 2.3. Analysis of the mineral contents and nutritional value 2.4. Cross the lines which possess the desired traits with the N61 and Sudanese cultivars to identify the QTLs and develop molecular markers for MAS 2.5. Introduce the high quality gene (Glu-D1d) to the genetic background of a Sudanese cultivar (Bohain) that maintain high bread making quality even under high temperature			<b>Pre-Conditions</b> • The vision and the mission of the ARC and Sudan government strategic plan to increase wheat production and realize self-sufficiency will be continued • Before the commencement of the project, ARC will finish to relocate the staff and to hand over the facility which supposed to be used as the breeding laboratory after renovation. • ARC secures the local component for this project to develop new wheat varieties in a continuous way. • Public security and political situation are not drastically deteriorated • Climate condition is not drastically changed
3.1. Detailed physiological evaluation for the tolerant and sensitive lines in the field and growth chambers 3.2. Analyze metabolites produced specifically in tolerant lines under stressed condition and identify the metabolites to reveal the mechanism of the tolerance to be used for selection 3.3. Identify genes usable for selection from the profile of tolerant lines mRNA			
4.1. Predict the climate of Sudan in 2050 from the past and present climate observation and rising CO2 concentration 4.2. Develop crop model for wheat production in different climate scenarios 4.3. Examine the response of the developed germplasm to the future climate scenarios 4.4. Develop climate smart agricultural crop production technologies (CSA)			
5.1. Conduct base line survey to determine the Project intervention areas 5.2. Conduct a monitoring and impact assessment studies 5.3. Produce officially categorized seeds 5.4. Establish Project website, multimedia contents for technology dissemination, communication and awareness among the stakeholders 5.5. Establish innovation platform for all stakeholders among the wheat value chain 5.6. Conduct degree trainings in Japan			

\* Innovation Platform: Virtual space where different stakeholders interact to better understand each other, learn and develop shared priorities, define roles and agree on joint actions towards





Project Title: Project for 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

Implementing Agency: Agricultural Research Corporation (ARC), Sudan Metrological Authority (SMA)

Target Group: Researchers and Technicians of ARC, SMA and farmers

Period of Project: 5 years

Project Site: Wad Medani

Experimental Site: Hudeiba, Dongola, New Halfa

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumption
<b>Overall Goal</b> Climate change resilient and nutritious candidate wheat varieties are newly developed by ARC	At least two (2) new candidate varieties are developed	Annual Report of ARC Ex-Post Evaluation of the Project	
<b>Project Purpose</b> Climate change resilient and nutritious wheat germplasm and the appropriate wheat production method are developed, and that information is shared with the people concerned with the wheat production	1. The seminar on the results of the Project is organized 2. At least three (3) reports related to the Project are published by the international journals	1. The proceeding of the seminar on the results of the Project 2. The Project completion report 3. International journals	ARC secures enough budget even after the end of the project and continues to develop new wheat varieties using the wheat germplasm identified by the Project
<b>Outputs</b>			
1. Heat, water deficit tolerant and nutrient-use efficient wheat lines are developed using modern technologies	Ten (10) elite wheat lines with enhanced tolerance to heat and water deficit stress with better nutritional value and more efficient in resource utilization are made available	The publications and project reports	Something uncontrollable that would delay the activities of the Project will not happen
2. Nutritional value and end use quality of wheat are enhanced under the heat-stressed environments of Sudan	Germplasm with enhanced nutritional value is identified	1. The publication and Project reports 2. The Project impacts assessment survey	
3. Mechanisms behind heat and water-deficit stress tolerance, and better utilization of nutrients are clarified and information is made available to be utilized in future breeding strategies	3.1. At least two (2) mechanisms behind heat and water-deficit stress tolerance, and better utilization of nutrients are clarified and information are made available 3.2. Data-server for the analysis of at least ten (10) sets of omics data are made available	1. The publications and project reports	
4.1. Wheat production scenarios in Sudan for future climate change are developed 4.2. Sustainable, environmentally friendly and appropriate wheat production technologies are developed	4.1. Alternative scenarios and models for wheat production are made available 4.2. Two wheat production technologies are developed	1. The publications and project reports 2. The project reports and the Proceedings of the National Husbandry committee of the Sudan Ministry of Agriculture	
5. Capacity of researchers and farmers are strengthened and interaction among different stakeholders are enhanced for increased and sustainable wheat production	(Innovation Platform (IPs)) * 5.1. Five (5) IPs are established 5.2. Five hundred (500) farmers in total are directly involved in IP activities 5.3. Productivity of directly participating farmers increases by 20% 5.4. Fifteen thousands (15,000) people view the contents of the web site and the multimedia provided by the Project (Capacity Development) 5.5. Ten (10) MSc or PhD degrees are obtained	1. The project reports	
<b>Activities</b>	<b>Inputs</b>		<b>Important Assumption</b>
	<b>The Japanese side</b>	<b>The Sudanese side</b>	
1.1. Multilocation evaluation for selection and confirmation of the desired lines 1.2. Development of RILs for each of the desired traits, genotyping and QTLs identification 1.3. Development of PCR markers for the identified QTLs 1.4. QTLs pyramiding in the background of N61 and Sudanese cultivar 1.5. Initiate and establish MAS to transfer the desired QTLs to Sudanese wheat genetic background 1.6. New lines registration 1.7. Establish future breeding strategies based on climate analysis output 1.8. Selection of ABA hyper-sensitive line for drought tolerance and QTL analysis	1. Allocation of the Japanese experts 2. Machinery and Vehicle procurement and maintenance 3. Establish molecular and speed breeding facility 4. Equipment's for molecular and speed breeding 5. Twenty-Five (25) Short and medium-term specialized trainings in Japan and Sudan for Project counterparts and other IP stakeholders 6. Local cost for the activities for the different activities of the Project	1. Allocation of the counterpart personnel 2. Provision of offices and necessary space for the Japanese experts 3. Local cost (salary of the personnel, utilization of existing machinery and equipment, maintenance and running cost of the machinery) 4. Provision of postgraduate degree assistantship in local universities 5. Provision of experimental farms and laboratory space at all sites	• Electricity, Water, Basic Infrastructure, Materials necessary for the experiments (regents, chemicals, samples in the processing of mRNA to cDNA in the molecular genetics study) are available
2.1. Examine the seed characters and quality parameters of lines grown under heat and stress conditions 2.2. Analysis of protein content and bread making quality 2.3. Analysis of the mineral contents and nutritional value 2.4. Cross the lines which possess the desired traits with the N61 and Sudanese cultivars to identify the QTLs and develop molecular markers for MAS 2.5. Introduce the high quality gene (Glu-D1d) to the genetic background of a Sudanese cultivar (Bohain) that maintain high bread making quality even under high temperature			<b>Pre-Conditions</b> • The vision and the mission of the ARC and Sudan government strategic plan to increase wheat production and realize self-sufficiency will be continued • Before the commencement of the project, ARC will finish to relocate the staff and to hand over the facility which supposed to be used as the breeding laboratory after renovation. • ARC secures the local component for this project to develop new wheat varieties in a continuous way. • Public security and political situation are not drastically deteriorated • Climate condition is not drastically changed
3.1. Detailed physiological evaluation for the tolerant and sensitive lines in the field and growth chambers 3.2. Analyze metabolites produced specifically in tolerant lines under stressed condition and identify the metabolites to reveal the mechanism of the tolerance to be used for selection 3.3. Identify genes usable for selection from the profile of tolerant lines mRNA			
4.1. Predict the climate of Sudan in 2050 from the past and present climate observation and rising CO2 concentration 4.2. Develop crop model for wheat production in different climate scenarios 4.3. Examine the response of the developed germplasm to the future climate scenarios 4.4. Develop climate smart agricultural crop production technologies (CSA)			
5.1. Conduct base line survey to determine the Project intervention areas 5.2. Conduct a monitoring and impact assessment studies 5.3. Produce officially categorized seeds 5.4. Establish Project website, multimedia contents for technology dissemination, communication and awareness among the stakeholders 5.5. Establish innovation platform for all stakeholders among the wheat value chain 5.6. Conduct degree trainings in Japan			

\* Innovation Platform: Virtual space where different stakeholders interact to better understand each other, learn and develop shared priorities, define roles and agree on joint actions towards





### Annex 3-4.1. Project Design Matrix version 3

**Project Title:** Project for 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

**Implementing Agency:** Agricultural Research Corporation (ARC), Sudan Metrological Authority (SMA)

**Target Group:** Researchers and Technicians of ARC, SMA and farmers

**Period of Project:** 5 years

**Project Site:** Wad Medani

**Experimental Site:** Hudeiba, Dongola, New Halfa

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumption
<b>Overall Goal</b> Climate change resilient and nutritious candidate wheat varieties are newly developed by ARC	At least two (2) new candidate varieties are developed	Annual Report of ARC Ex-Post Evaluation of the Project	
<b>Project Purpose</b> Climate change resilient and nutritious wheat germplasm and the appropriate wheat production method are developed, and that information is shared with the people concerned with the wheat production	1. The seminar on the results of the Project is organized 2. At least three (3) reports related to the Project are published by the international journals	1. The proceeding of the seminar on the results of the Project 2. The Project completion report 3. International journals	ARC secures enough budget and continues to develop the new wheat varieties using the wheat germplasm identified by the Project
<b>Outputs</b> 1. Heat, water deficit tolerant and nutrient-use efficient wheat lines are developed using modern technologies 2. Nutritional value and end use quality of wheat are enhanced under the heat-stressed environments of Sudan 3. Mechanisms behind heat and water-deficit stress tolerance, and better utilization of nutrients are clarified and information is made available to be utilized in future breeding strategies	Ten (10) elite wheat lines with enhanced tolerance to heat and water deficit stress with better nutritional value and more efficient in resource utilization are made available  Germplasm with enhanced nutritional value is identified  3.1. At least two (2) mechanisms behind heat and water-deficit stress tolerance, and better utilization of nutrients are clarified and information are made available 3.2. Data-server for the analysis of at least ten (10) sets of omics data are made available	The publications and project reports  1. The publication and Project reports 2. The Project impacts assessment survey  1. The publications and project reports	Something uncontrollable that would delay the activities of the Project will not happen
4.1. Wheat production scenarios in Sudan for future climate change are developed 4.2. Sustainable, environmentally friendly and appropriate wheat production technologies are developed	4.1. Alternative scenarios and models for wheat production are made available 4.2. Two wheat production technologies are developed	1. The publications and project reports 2. The project reports and the Proceedings of the National Husbandry committee of the Sudan Ministry of Agriculture	
5. Capacity of researchers and farmers are strengthened and interaction among different stakeholders are enhanced for increased and sustainable wheat production	(Innovation Platform (IP)) * 5.1. Five (5) IPs are established 5.2. Five hundred (500) farmers in total are directly involved in IP activities 5.3. Productivity of directly participating farmers increases by 20% 5.4. Fifteen thousands (15,000) people view the contents of the web site and the multimedia provided by the Project. (Capacity Development) 5.5. Six (6) -MSc or PhD degrees are obtained	1. The project reports	

\* Innovation Platform: Virtual space where different stakeholders interact to better understand each other, learn and develop shared priorities, define roles and agree on joint actions towards realization of the agricultural revival and development

Activities	Inputs		Important Assumption
	The Japanese side	The Sudanese side	
1.1. Multilocation evaluation for selection and confirmation of the desired lines 1.2. Development of RILs for each of the desired traits, genotyping and QTLs identification 1.3. Development of PCR markers for the identified QTLs 1.4. QTLs pyramiding in the background of N61 and Sudanese cultivar 1.5. Initiate and establish MAS to transfer the desired QTLs to Sudanese wheat genetic background 1.6. New lines registration 1.7 Produce early generation seeds (breeder and pre-basic seeds) 1.8. Establish future breeding strategies based on climate analysis output 1.9. Selection of ABA hyper-sensitive line for drought tolerance and QTL analysis	1. Allocation of the Japanese experts 2. Machinery and Vehicle procurement and maintenance 3. Establish molecular and speed breeding facility 4. Equipment's for molecular and speed breeding 5. Twenty-Five (25) Short and medium-term specialized trainings in Japan and Sudan for Project counterparts and other IP stakeholders  6. Local cost for the activities for the different activities of the Project	1. Allocation of the counterpart personnel 2. Provision of offices and necessary space for the Japanese experts 3. Local cost (salary of the personnel, utilization of existing machinery and equipment, maintenance and running cost of the machinery) 4. Provision of postgraduate degree assistantship in local universities 5. Provision of experimental farms and laboratory space at all sites	<ul style="list-style-type: none"> <li>Electricity, Water, Basic Infrastructure, Materials necessary for the experiments (regents, chemicals, samples in the processing of mRNA to cDNA in the molecular genetics study) are available</li> </ul>
2.1. Examine the seed characters and quality parameters of lines grown under heat and stress conditions 2.2. Analysis of protein content and bread making quality 2.3. Analysis of the mineral contents and nutritional value 2.4. Cross the lines which possess the desired traits with the N61 and Sudanese cultivars to identify the QTLs and develop molecular markers for MAS 2.5. Introduce the high quality gene (Glu-D1d) to the genetic background of a Sudanese cultivar (Bohain) that maintain high bread making quality even under high temperature			
3.1. Detailed physiological evaluation for the tolerant and sensitive lines in the field and growth chambers 3.2. Analyze metabolites produced specifically in tolerant lines under stressed condition and identify the metabolites to reveal the mechanism of the tolerance to be used for selection 3.3. Identify genes usable for selection from the profile of tolerant lines mRNA			
4.1. Predict the climate of Sudan in 2050 from the past and present climate observation and rising CO2 concentration 4.2. Develop crop model for wheat production in different climate scenarios 4.3. Examine the response of the developed germplasm to the future climate scenarios 4.4. Develop climate smart agricultural crop production technologies (CSA)			
5.1. Conduct base line survey to determine the Project intervention areas 5.2. Conduct a monitoring and impact assessment studies 5.3. Produce officially categorized seeds 5.4. Establish Project website, multimedia contents for technology dissemination, communication and awareness among the stakeholders 5.5. Establish innovation platform for all stakeholders among the wheat value chain 5.6. Conduct degree and non-degree trainings in Japan and Sudan			<b>Pre-Conditions</b> <ul style="list-style-type: none"> <li>The vision and the mission of the ARC and Sudan government strategic plan to increase wheat production and realize self-sufficiency will be continued</li> <li>Before the commencement of the project, ARC will finish to relocate the staff and to hand over the facility which supposed to be used as the breeding laboratory after renovation.</li> <li>ARC secures the local component for this project to develop new wheat varieties in a continuous way.</li> <li>Public security and political situation are not drastically deteriorated</li> <li>Climate condition is not drastically changed</li> </ul>





Project Title: Project for 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

Implementing Agency: Agricultural Research Corporation (ARC), Sudan Metrological Authority (SMA)

Target Group: Researchers and Technicians of ARC, SMA and farmers

Period of Project: 5 years

Project Site: Wad Medani

Experimental Site: Hudeiba, Dongola, New Halfa

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumption	Achievement	Remarks
<b>Overall Goal</b> Climate change resilient and nutritious candidate wheat varieties are newly developed by ARC	Two (2) or three (3) new candidate varieties are developed	Annual Report of ARC Ex-Post Evaluation of the Project			
<b>Project Purpose</b> Climate change resilient and nutritious wheat germplasm and the appropriate wheat production method are developed, and that information is shared with the people concerned with the wheat production	1. The seminar on the results of the Project is organized 2. At least three (3) reports related to the Project are published by the international journals	1. The proceeding of the seminar on the results of the Project 2. The Project completion report 3. International journals	ARC secures enough budget and continues to develop the new wheat varieties using the wheat germplasm identified by the Project		
<b>Outputs</b> 1. Heat, water deficit tolerant and nutrient-use efficient wheat lines are developed using modern technologies	Ten (10) elite wheat lines with enhanced tolerance to heat and water deficit stress with better nutritional value and more efficient in resource utilization are made available	The publications and project reports	Something uncontrollable that would delay the activities of the Project will not happen		
2. Nutritional value and end use quality of wheat are enhanced under the heat-stressed environments of Sudan	Germplasm with enhanced nutritional value is identified	1. The publication and Project reports 2. The Project impacts assessment survey			
3. Mechanisms behind heat and water-deficit stress tolerance, and better utilization of nutrients are clarified and information is made available to be utilized in future breeding strategies	3.1. Two (2) or three (3) mechanisms behind heat and water-deficit stress tolerance, and better utilization of nutrients are clarified and information are made available 3.2. Data-server for the analysis of at least ten (10) sets of omics data are made available	1. The publications and project reports			
4.1. Wheat production scenarios in Sudan for future climate change are developed 4.2. Sustainable, environmentally friendly and appropriate wheat production technologies are developed	4.1. Alternative scenarios and models for wheat production are made available 4.2. Two wheat production technologies are developed	1. The publications and project reports 2. The project reports and the Proceedings of the National Husbandry committee of the Sudan Ministry of Agriculture			
5. Capacity of researchers and farmers are strengthened and interaction among different stakeholders are enhanced for increased and sustainable wheat production	(Innovation Platform (IP)) * 5.1. Five (5) IPs are established 5.2. Five hundred (500) farmers in total are directly involved in IP activities 5.3. Productivity of directly participating farmers increases by 20% 5.4. The xx viewers of the contents provided by the Project are reached (Capacity Development) 5.5. Six (6) MSc or PhD degrees are obtained	1. The project reports			

\* Innovation Platform: Virtual space where different stakeholders interact to better understand each other, learn and develop shared priorities, define roles and agree on joint actions towards realization of the agricultural revival and development

Activities	Inputs		Important Assumption	
	The Japanese side	The Sudanese side		
<p>1.1. Multilocation evaluation for selection and confirmation of the desired lines</p> <p>1.2. Development of RILs for each of the desired traits, genotyping and QTLs identification</p> <p>1.3. Development of PCR markers for the identified QTLs</p> <p>1.4. QTLs pyramiding in the Background of N61 and Sudanese cultivar</p> <p>1.5. Initiate and establish MAS to transfer the desired QTLs to Sudanese wheat genetic background</p> <p>1.6. New lines registration</p> <p>1.7. Produce officially categorized seeds</p> <p>1.8. Establish future breeding strategies based on climate analysis output</p> <p>1.9. Selection of ABA hyper-sensitive line for drought tolerance and QTL analysis</p>	<p>1. Allocation of the Japanese experts</p> <p>2. Machinery and Vehicle procurement and maintenance</p> <p>3. Establish molecular and speed breeding facility</p> <p>4. Equipment's for molecular and speed breeding</p> <p>5. Twenty-Five (25) Short and medium-term specialized trainings in Japan and Sudan for Project counterparts and other IP stakeholders</p> <p>6. Local cost for the activities for the different activities of the Project</p>	<p>1. Allocation of the counterpart personnel</p> <p>2. Provision of offices and necessary space for the Japanese experts</p> <p>3. Local cost (salary of the personnel, utilization of existing machinery and equipment, maintenance and running cost of the machinery)</p> <p>4. Provision of postgraduate degree assistantship in local universities</p> <p>5. Provision of experimental farms and laboratory space at all sites</p>	<p>Electricity, Water, Basic Infrastructure, Materials necessary for the experiments (regents, chemicals, samples in the processing of mRNA to cDNA in the molecular genetics study) are available</p>	<p>1.1 Multilocation evaluation conducted for two seasons for different sets of genotypes. One experiment has been conducted in Nigeria.</p> <p>1.2 Four RILs populations developed, genotyped and being evaluated. Additional three RILs were developed.</p> <p>1.7 Breeder and basic seeds necessary for the IP seed production made available.</p> <p>1.9.1 Potential lines have been selected and crossed to develop the QTL mapping population.</p> <p>1.9.2 The F2 generation was genotyped for QTL analysis.</p> <p>1.9.3 Metabolome analysis has been conducted using GC-MS.</p> <p>Published papers  <i>Kamal et al.</i> doi: 10.3390/ijms20235837  <i>Mahjoob et al. (a)</i> <a href="http://doi.org/10.3390/plants10020211">http://doi.org/10.3390/plants10020211</a>  <i>Mahjoob et al. (b)</i> <a href="http://doi.org/10.3390/d13050217">http://doi.org/10.3390/d13050217</a>  <i>Itam et al. (a)</i> <a href="http://doi.org/10.3390/agronomy11061061">http://doi.org/10.3390/agronomy11061061</a>  <i>Itam et al. (b)</i> <a href="http://doi.org/10.1007/s00122-021-03969-x">http://doi.org/10.1007/s00122-021-03969-x</a></p>
<p>2.1. Examine the seed characters and quality parameters of lines grown under heat and stress conditions</p> <p>2.2. Analysis of protein content and bread making quality</p> <p>2.3. Analysis of the mineral contents and nutritional value</p> <p>2.4. Cross the lines which possess the desired traits with the N61 and Sudanese cultivars to identify the QTLs and develop molecular markers for MAS</p> <p>2.5. Introduce the high quality gene (Glu-D1d) to the genetic background of a Sudanese cultivar (Boham) that maintain high bread making quality even under high temperature</p>				<p>2.1. Two papers are published.  <i>Elhadi et al. (a)</i> <a href="http://doi.org/10.3390/ijms22041830">http://doi.org/10.3390/ijms22041830</a>  <i>Elhadi et al. (b)</i> <a href="http://doi.org/10.3390/agronomy11061061">http://doi.org/10.3390/agronomy11061061</a></p> <p>2.3. Materials for analysis are prepared.</p> <p>2.4. One paper is published.  <i>Tanaka et al.</i> <a href="http://doi.org/10.1270/jcbb.20080">http://doi.org/10.1270/jcbb.20080</a></p> <p>2.5. Plant materials are growing.</p>
<p>3.1. Detailed physiological evaluation for the tolerant and sensitive lines in the field and growth chambers</p> <p>3.2. Analyze metabolites produced specifically in tolerant lines under stressed condition and identify the metabolites to reveal the mechanism of the tolerance to be used for selection</p> <p>3.3. Identify genes usable for selection from the profile of tolerant lines mRNA</p>				<p>3.1. Physiology and agronomic traits of tolerant and sensitive lines were evaluated, and one paper was published.  <i>Itam et al. (c)</i> <a href="https://doi.org/10.1038/s41598-020-74303-6">https://doi.org/10.1038/s41598-020-74303-6</a>  <i>Itam et al. (d)</i> <a href="https://doi.org/10.3390/agronomy10101588">https://doi.org/10.3390/agronomy10101588</a>  <i>Matsunaga et al.</i> <a href="https://doi.org/10.3390/ijms22136942">https://doi.org/10.3390/ijms22136942</a></p> <p>3.2. Metabolic profile of the representative tolerant line were analyzed and the databases were constructed.</p> <p>3.3. Data was taken on the mRNA transcriptome of the reference line under heat stress.</p>
<p>4.1. Predict the climate of Sudan in 2050 from the past and present climate observation and rising CO2 concentration</p> <p>4.2. Develop crop model for wheat production in different climate scenarios</p> <p>4.3. Analyze the economic impact of the wheat production on the national economy in different climate scenario</p> <p>4.4. Examine the response of the developed germplasm to the future climate scenarios</p> <p>4.5. Develop climate smart agricultural crop production technologies (CSA)</p>				<p>4.1. Two papers are published.  <i>Iizumi et al.</i> <a href="http://doi.org/10.1038/s43016-020-00214-4">http://doi.org/10.1038/s43016-020-00214-4</a>  <i>Musa et al.</i> <a href="http://doi.org/10.1007/s00704-021-03690-1">http://doi.org/10.1007/s00704-021-03690-1</a></p> <p>4.2. The prototype model has been developed.</p> <p>4.5. The early warning system has been designed.</p>

<p>5.1. Conduct base line survey to determine the Project intervention areas</p> <p>5.2. Conduct a monitoring and impact assessment studies</p> <p>5.3. Produce officially categorized seeds</p> <p>5.4. Establish Project website, multimedia contents for technology dissemination, communication and awareness among the stakeholders</p> <p>5.5. Establish innovation platform for all stakeholders among the wheat value chain</p> <p>5.6. Conduct degree and non-degree trainings in Japan and Sudan</p>			<p>Pre-Conditions</p> <ul style="list-style-type: none"> <li>• The vision and the mission of the ARC and Sudan government strategic plan to increase wheat production and realize self-sufficiency will be continued</li> <li>• Public security and political situation are not drastically deteriorated</li> <li>• Climate condition is not drastically changed</li> </ul>	<p>5.1. The base line surveys were conducted and achieved.</p> <p>5.2. Two progress meetings conducted online.</p> <p>5.3. Seeds necessary for the IP operation produced.</p> <p>5.4.1. Website, YouTube channel and SNS are published.</p> <p>5.4.2. Four TV and radio interviews conducted. About 5000 people reached.</p> <p>5.5.1. Three IP sites have been established.</p> <p>5.5.2. Workshop training for 26 extension staffs conducted.</p> <p>5.5.3. Three field and harvest days organized involving 150 stakeholders.</p> <p>5.6.1. Two short-term trainees were trained.</p> <p>5.6.2. Seven long-term trainees (Ph.D. students) have been enrolled in Tottori University.</p> <p>Published paper  <i>Izzat et al. <a href="http://doi.org/10.1080/14735903.2020.1787639">http://doi.org/10.1080/14735903.2020.1787639</a></i></p>	
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**Project Title:** Project for 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

**Implementing Agency:** Agricultural Research Corporation (ARC), Sudan Metrological Authority (SMA)

**Target Group:** Researchers and Technicians of ARC, SMA and farmers

**Period of Project:** 5 years

**Project Site:** Wad Medani

**Experimental Site:** Hudeiba, Dongola, New Halfa

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumption	Achievement	Remarks
<p><b>Overall Goal</b> Climate change resilient and nutritious candidate wheat varieties are newly developed by ARC</p>	Two (2) or three (3) new candidate varieties are developed	Annual Report of ARC Ex-Post Evaluation of the Project			
<p><b>Project Purpose</b> Climate change resilient and nutritious wheat germplasm and the appropriate wheat production method are developed, and that information is shared with the people concerned with the wheat production</p>	1. The seminar on the results of the Project is organized 2. At least three (3) reports related to the Project are published by the international journals	1. The proceeding of the seminar on the results of the Project 2. The Project completion report 3. International journals	ARC secures enough budget and continues to develop the new wheat varieties using the wheat germplasm identified by the Project		
<p><b>Outputs</b> 1. Heat, water deficit tolerant and nutrient-use efficient wheat lines are developed using modern technologies 2. Nutritional value and end use quality of wheat are enhanced under the heat-stressed environments of Sudan 3. Mechanisms behind heat and water-deficit stress tolerance, and better utilization of nutrients are clarified and information is made available to be utilized in future breeding strategies</p>	Ten (10) elite wheat lines with enhanced tolerance to heat and water deficit stress with better nutritional value and more efficient in resource utilization are made available	The publications and project reports	Something uncontrollable that would delay the activities of the Project will not happen		
<p>4.1. Wheat production scenarios in Sudan for future climate change are developed 4.2. Sustainable, environmentally friendly and appropriate wheat production technologies are developed</p>	Germplasm with enhanced nutritional value is identified	1. The publication and Project reports 2. The Project impacts assessment survey			
<p>5. Capacity of researchers and farmers are strengthened and interaction among different stakeholders are enhanced for increased and sustainable wheat production</p>	3.1. Two (2) or three (3) mechanisms behind heat and water-deficit stress tolerance, and better utilization of nutrients are clarified and information are made available 3.2. Data-server for the analysis of at least ten (10) sets of omics data are made available	1. The publications and project reports			
	4.1. Alternative scenarios and models for wheat production are made available 4.2. Two wheat production technologies are developed	1. The publications and project reports 2. The project reports and the Proceedings of the National Husbandry committee of the Sudan Ministry of Agriculture			
	(Innovation Platform (IP)) * 5.1. Five (5) IPs are established 5.2. Five hundred (500) farmers in total are directly involved in IP activities 5.3. Productivity of directly participating farmers increases by 20% 5.4. The xx viewers of the contents provided by the Project are reached (Capacity Development) 5.5. Six (6) MSc or PhD degrees are obtained	1. The project reports			

\* Innovation Platform: Virtual space where different stakeholders interact to better understand each other, learn and develop shared priorities, define roles and agree on joint actions towards realization of the agricultural revival and development

Activities	Inputs		Important Assumption	Achievement	Remarks
	The Japanese side	The Sudanese side			
<p>1.1. Multilocation evaluation for selection and confirmation of the desired lines</p> <p>1.2. Development of RILs for each of the desired traits, genotyping and QTLs identification</p> <p>1.3. Development of PCR markers for the identified QTLs</p> <p>1.4. QTLs pyramiding in the Background of N61 and Sudanese cultivar</p> <p>1.5. Initiate and establish MAS to transfer the desired QTLs to Sudanese wheat genetic background</p> <p>1.6. New lines registration</p> <p>1.7. Produce officially categorized seeds</p> <p>1.8. Establish future breeding strategies based on climate analysis output</p> <p>1.9. Selection of ABA hyper-sensitive line for drought tolerance and QTL analysis</p>	<p>1. Allocation of the Japanese experts</p> <p>2. Machinery and Vehicle procurement and maintenance</p> <p>3. Establish molecular and speed breeding facility</p> <p>4. Equipment's for molecular and speed breeding</p> <p>5. Twenty-Five (25) Short and medium-term specialized trainings in Japan and Sudan for Project counterparts and other IP stakeholders</p> <p>6. Local cost for the activities for the different activities of the Project</p>	<p>1. Allocation of the counterpart personnel</p> <p>2. Provision of offices and necessary space for the Japanese experts</p> <p>3. Local cost (salary of the personnel, utilization of existing machinery and equipment, maintenance and running cost of the machinery)</p> <p>4. Provision of postgraduate degree assistantship in local universities</p> <p>5. Provision of experimental farms and laboratory space at all sites</p>	<p>• Electricity, Water, Basic Infrastructure, Materials necessary for the experiments (regents, chemicals, samples in the processing of mRNA to cDNA in the molecular genetics study) are available</p>	<p>1.1 Multilocation evaluation conducted for two seasons for different sets of genotypes. The 1st and 2nd Elite SATREPS Yield Trials have been sent to Nigeria and DRC, respectively.</p> <p>1.2 Four RILs populations developed, genotyped and being evaluated. Additional three RILs were developed.</p> <p>1.7 Breeder and basic seeds necessary for the IP seed production made available.</p> <p>1.9.1 Potential lines have been selected and crossed to develop the QTL mapping population.</p> <p>1.9.2 The F2 generation was genotyped for QTL analysis.</p> <p>1.9.3 Metabolome analysis has been conducted using GC-MS.</p> <p>Published papers  <i>Kamal et al. doi: 10.3390/ijms20235837</i>  <i>Mahjoob et al. (a) http://doi.org/10.3390/plants10020211</i>  <i>Mahjoob et al. (b) http://doi.org/10.3390/d13050217</i>  <i>Itam et al. (a) http://doi.org/10.3390/agronomy11061061</i>  <i>Itam et al. (b) http://doi.org/10.1007/s00122-021-03969-x</i>  <i>Balla et al. https://doi.org/10.1007/s00122-022-04062-7</i></p>	<p>1.1 70%</p> <p>1.2 90%</p> <p>1.3 20%</p> <p>1.4 10%</p> <p>1.5 5%</p> <p>1.6 5%</p> <p>1.7 80%</p> <p>1.8 10%</p> <p>1.9 50%</p>
<p>2.1. Examine the seed characters and quality parameters of lines grown under heat and stress conditions</p> <p>2.2. Analysis of protein content and bread making quality</p> <p>2.3. Analysis of the mineral contents and nutritional value</p> <p>2.4. Cross the lines which possess the desired traits with the N61 and Sudanese cultivars to identify the QTLs and develop molecular markers for MAS</p> <p>2.5. Introduce the high quality gene (Glu-D1d) to the genetic background of a Sudanese cultivar (Bohain) that maintain high bread making quality even under high temperature</p>				<p>2.1. Two papers are published.  <i>Ehadi et al. (a) http://doi.org/10.3390/ijms22041830</i>  <i>Ehadi et al. (b) http://doi.org/10.3390/agronomy11061061</i></p> <p>2.2. One paper is ready to be published and another is being prepared for submission.</p> <p>2.3. Materials for analysis are examined.</p> <p>2.4. One paper is published.  <i>Tanaka et al. http://doi.org/10.1270/jsbbs.20080</i></p> <p>2.5. Breadings are ongoing.</p>	<p>2.1: 100%</p> <p>2.2: 90%</p> <p>2.3: 75%</p> <p>2.4: 80%</p> <p>2.5: 80%</p>
<p>3.1. Detailed physiological evaluation for the tolerant and sensitive lines in the field and growth chambers</p> <p>3.2. Analyze metabolites produced specifically in tolerant lines under stressed condition and identify the metabolites to reveal the mechanism of the tolerance to be used for selection</p> <p>3.3. Identify genes usable for selection from the profile of tolerant lines mRNA</p>				<p>3.1. Physiology and agronomic traits of tolerant and sensitive lines were evaluated, and four papers are published.  <i>Itam et al.(c) https://doi.org/10.1038/s41598-020-74303-6</i>  <i>Itam et al.(d) https://doi.org/10.3390/agronomy10101588</i>  <i>Matsunaga et al.(a) https://doi.org/10.3390/ijms22136942</i>  <i>Matsunaga et al.(b) https://doi.org/10.3390/ijms222313139</i>  <i>Osman et al. http://doi.org/10.3390/ijms23052842</i></p> <p>3.2. Metabolic profile of the representative tolerant line were analyzed and the databases were constructed.</p> <p>3.3. Data was taken on the mRNA transcriptome of the reference line under heat stress.</p> <p>a) Molecular mechanisms for heat stress tolerance by (i) metabolic regulation of unique set of tolerance related amino acids and (ii) alteration of cell wall component were identified.  b) Eight (8) sets of omics data for the heat stress responses were constructed.</p>	<p>3.1: 80%</p> <p>3.2: 80%</p> <p>3.3: 40%</p>
<p>4.1. Predict the climate of Sudan in 2050 from the past and present climate observation and rising CO2 concentration</p> <p>4.2. Develop crop model for wheat production in different climate scenarios</p> <p>4.3. Analyze the economic impact of the wheat production on the national economy in different climate scenario</p> <p>4.4. Examine the response of the developed germplasm to the future climate scenarios</p> <p>4.5. Develop climate smart agricultural crop production technologies (CSA)</p>				<p>4.1. Two papers are published.  <i>Izumi et al. http://doi.org/10.1038/s43016-020-00214-4</i>  <i>Musa et al.(a) http://doi.org/10.1007/s00704-021-03690-1</i></p> <p>4.2. The prototype model has been developed.</p> <p>4.5. The early warning system has been designed.  One paper is published.  <i>Musa et al. (b) https://doi.org/10.3390/atmos13040572</i></p>	<p>4.1. 100%</p> <p>4.2. 50%</p> <p>4.3. 5%</p> <p>4.4. 10%</p> <p>4.5. 60%</p>

<p>5.1. Conduct base line survey to determine the Project intervention areas  5.2. Conduct a monitoring and impact assessment studies  5.3. Produce officially categorized seeds  5.4. Establish Project website, multimedia contents for technology dissemination, communication and awareness among the stakeholders  5.5. Establish innovation platform for all stakeholders among the wheat value chain  5.6. Conduct degree and non-degree trainings in Japan and Sudan</p>			<p>Pre-Conditions  • The vision and the mission of the ARC and Sudan government strategic plan to increase wheat production and realize self-sufficiency will be continued  • Public security and political situation are not drastically deteriorated  • Climate condition is not drastically changed</p>	<p>5.1. The baseline surveys were conducted and achieved.  5.2. Two progress meetings were conducted online. (ongoing activity)  5.3. Seeds necessary for the IP operation produced. (ongoing activity)  5.4.1. Website, YouTube channel, and SNS are published.  5.4.2. Four TV and radio interviews were conducted. About 5000 people reached.  5.5.1. Six IP sites have been established.  5.5.2. Three training workshop conducted.  5.5.3. Five field and harvest days organized  5.6.1. Two short-term trainees were trained.  5.6.2. Seven long-term trainees (Ph.D. students) have been enrolled in Tottori University.   Documents:  <a href="https://www.youtube.com/channel/UCX19GxvyXSWFpLwj08ym0WA/videos">https://www.youtube.com/channel/UCX19GxvyXSWFpLwj08ym0WA/videos</a>  -Anonymous: Technological Options for Sustainable Wheat Production in Sudan. Agricultural Research Corporation, Wheat Research Program. Wad Medani, Sudan, p24 (2020). Financially supported by SATREPS Wheat Project funded by JICA/JST.</p>	<p>5.1 100%  5.2 50%  5.3 70%  5.4 100%  5.5 120%  5.6 60%</p>
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Output 2: Nutritional value and end use quality of wheat are enhanced under the heat-stressed environments of Sudan																									
2.1. Examine the seed characters and quality parameters of lines grown under heat and stress conditions	Plan																								
	Actual																							1. Seed characters of all the MSD lines grown under normal condition in Japan has been measured. 2. Seed characters of 140 selected MSD lines grown under stress conditions in Sudan has been analyzed. These 140 lines do not require vernalization treatment and are adapted to Sudanese conditions. 3. All the MSD lines were genotyped using the DArT-seq platform. GWAS conducted and new QTLs have been identified. On these three points, we have completed our experiments and published two papers.	
2.2. Analysis of protein content and bread making quality	Plan																								
	Actual																							Protein content and bread making quality have been measured in 103 selected MSD lines. These 103 lines have high-molecular-weight glutenin subunits derived from <i>Aegilops tauschii</i> . We have completed our experiments, one paper is under peer review and another is being prepared for submission.	
2.3. Analysis of the mineral contents and nutritional value	Plan																								
	Actual																							Analysis of starch composition, which is the main component of seed and greatly affects seed characters like Activity 2.1, has been started. We have completed a study of the starch composition of major Sudanese varieties under normal conditions and heat stress.	
2.4. Cross the lines possess the desired traits with the N61 and Sudanese cultivars to identify the QTLs and develop molecular markers for MAS	Plan																								
	Actual																							Promising genetic resources in Sudanese cultivar were found. Crossing and experiments have been started. We have published one paper on promising Sudan varieties. We are also continuing to breed lines using these varieties.	
2.5. Introduce the high quality gene (Glu-D1d) to the genetic background of a Sudanese cultivar (Bohain) that maintain high BMQ even under high temperature	Plan																								
	Actual																							Bohain has been crossed with the <i>Glu-D1d</i> gene donor, and the generation are being advanced. We are continuing to breed lines.	
<b>Output 3: Mechanisms behind heat and water-deficit stress tolerance, and better utilization of nutrients are clarified and information is made available to be utilized in future breeding strategies</b>																									
3.1. Detailed physiological evaluation for the tolerant and sensitive lines in the field and growth chambers	Plan																								
	Actual																							Experiments were conducted under growth chamber condition and the tolerance of some MSD lines to heat stress has been confirmed.	
3.2. Analyze metabolites produced specifically in tolerant lines under stressed condition and identify the metabolites to reveal the mechanism of the tolerance and to be used for selection	Plan																								
	Actual																							Metabolome analysis was conducted, and we identified some potential metabolites related to heat stress adaptation.	
3.3. Identify genes usable for selection from the profile of tolerant lines mRNA	Plan																								
	Actual																							Experiments were conducted, and samples were sent for sequencing.	
<b>Output 4: Wheat production scenarios in Sudan and SSA for future climate change are developed Sustainable, environmentally-friendly and appropriate crop production technologies and innovations are developed</b>																									
4.1. Predict the climate of Sudan in 2050 from the past and present climate observation and rising CO2 concentration	Plan																								
	Actual																							Data for different climate scenarios were received, and the data analysis was carried out to confirm increasing temperature in the future.	
4.2. Develop crop model for wheat production in different climate scenarios	Plan																								
	Actual																							1. Agrometeorological station and temperature sensors have been installed in the field to monitor the crop canopy temperature in response to the stress. The data analysis shows difference in canopy temperature depression between cultivars. 2. Wheat yield estimated using the past climate data was compared with the actual yield data and the points to improve the crop model were identified, i.e. the relationship of the crop growth to its canopy temperature.	
4.3. Analyze the economic impact of the wheat production on the national economy in different climate scenario	Plan																								
	Actual																							Analysis have been started.	
4.4. Examine the response of the developed germplasm to the future climate scenarios	Plan																								
	Actual																							Crop model simulation for the developed cultivar is under preparation.	
4.5. Develop climate smart agricultural crop production technologies (CSA)	Plan																								
	Actual																							1. A climate early warning system is being developed to help farmers decide their options during the cropping season. 2. The downscaling of climate data has been successfully carried out and will be used for the early warning system.	
<b>Output 5: Capacity of researchers and farmers are strengthened and interaction among different stakeholders are enhanced for increased and sustainable wheat production</b>																									
5.1. Conduct base line survey to determine the project intervention areas	Plan																								
	Actual																							This activity achieved. A survey was conducted in Gezira, New Halfa, Northern, and River Nile states. The intervention sites were determined in principal.	
5.2. Conduct a monitoring and impact assessment	Plan																								
	Actual																							Two progress meeting were conducted online.	
5.3. Produce officially categorized seeds	Plan																								
	Actual																							Seeds were produced in 2019-20 and 2020-21 seasons.	
5.4. Establish project website, multimedia contents for technology dissemination, communication and awareness among the stakeholders	Plan																								
	Actual																							1. Home page and YouTube channel has been established. 2. Instructional videos about wheat production technologies published through project YouTube channel. 16000 views as of November 2021. 3. Booklet of wheat farming in Sudan was published. 4. Four TV and radio interviews conducted. About 5000 people reached	
5.5. Establish innovation platform for all stakeholders among the wheat value chain	Plan																								
	Actual																							1. IP in Gezira has been established in Nov. 2020. 2. IP in Northern state has been established in Mar. 2021. 3. IP in New Halfa has been established in Oct. 2021. 4. IP in River Nile state has been established in Oct. 2021 4. Three field and harvest days organized involving 150 stakeholders.	
5.6. Conduct degree and non-degree trainings in Japan and Sudan	Plan																								
	Actual																							1. Two short-term trainees were trained in Japan in the period of 1-28 September 2019. 2. Four students (Ph.D. course) have been enrolled in United Graduate School of Agricultural Sciences, Tottori University in October 2019. 3. Two students (Ph.D. course) have been enrolled in United Graduate School of Agricultural Sciences, Tottori University in April 2021. 4. Trainings for extension officers were conducted in Gezira and Northern States. 5. One long term trainee (Ph.D. Student) have been enrolled in the United Graduate School of Agricultural Sciences, Tottori University in Oct. 2021.	

Monitoring Plan		Year	2019				2020				2021				2022				2023				2024				Issue	Solution
			I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV						
Monitoring																												
Joint Coordinating Committee		Plan																									1. First JCC meeting was held in March 2020.	



**RECORD OF DISCUSSIONS**

**FOR**

**PROJECT FOR THE 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**

**AGREED UPON BETWEEN**

**AGRICULTURAL RESEARCH CORPORATION**

**OF**

**REPUBLIC OF SUDAN**

**AND**

**JAPAN INTERNATIONAL COOPERATION AGENCY**

**Dated February 4 2019**



Based on the minutes of meetings on the Detailed Planning Survey for the Project for the 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 (hereinafter referred to as "the Project") signed on 10 September 2018 between Agricultural Research Corporation of Sudan (hereinafter referred to as "the Counterpart") and the Japan International Cooperation Agency (hereinafter referred to as "JICA"), JICA held a series of discussions with the Counterpart and relevant organizations to develop a detailed plan of the Project.

The purpose of this record of discussions (hereinafter referred to as "the R/D") is to establish a mutual agreement for its implementation by both parties and to agree on the detailed plan of the Project as described in the followings and the Annexes, which will be implemented within the framework of the Note Verbales exchanged on 23 October 2018 between the Government of Japan and the Government of Sudan.

The Counterpart will be responsible for the implementation of the Project in cooperation with JICA, coordinate with other relevant organizations and ensure that the self-reliant operation of the Project is sustained during and after the implementation period in order to contribute toward social and economic development of Sudan.

Both parties also agreed that the Project will be implemented in accordance with the "Basic Principles for Technical Cooperation" published in December 2016 (hereinafter referred to as "the BP") attached as Annex 7, unless other arrangements are agreed in the R/D.

The R/D is delivered at Khartoum as of the day and year first above written. The R/D may be amended by a minutes of meetings between both parties, except the plan of operation to be modified in monitoring sheets. The minutes of meetings will be signed by authorized persons of each side who may be different from the signers of the R/D.

For

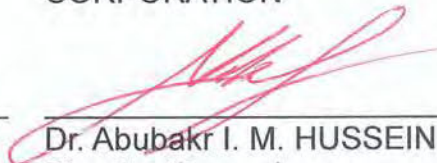
JAPAN INTERNATIONAL  
COOPERATION AGENCY



Makoto TAKAHASHI  
Chief Representative  
JICA Sudan Office

For

AGRICULTURAL RESEARCH  
CORPORATION



Dr. Abubakr I. M. HUSSEIN  
Director General

Witness by

For

Federal Ministry of Agriculture and  
Forests



Dr. Nabeel Ahmed Mohamed Saad  
Director General, International  
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For

Federal Ministry of Finance and  
Economic Planning



Mr. Musa Makin Kabashi  
Director General, General Directorate  
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Annex 1: Main Points Discussed

Annex 2: Project Design Matrix (PDM)

Annex 3: Plan of Operation (PO)

Annex 4: Implementation Structure

Annex 5: List of Proposed Members of Joint Coordinating Committee

Annex 6: Monitoring Form

Annex 7: Basic Principles for Technical Cooperation (December 2016)

## MAIN POINTS DISCUSSED

1. The program under which the Project is implemented:  
Both sides noted that the Project is implemented under the Science and Technology Research Partnership for Sustainable Development (hereinafter referred to as "SATREPS") program, promoted by JICA and Japan Science and Technology Agency (JST) in collaboration. SATREPS aims to develop new technologies and their applications for tackling global issues, and also aims at capacity development of researchers and research institutes in both countries.
2. Implementation Structure:  
The project organization chart is given in the Annex 4. The roles and assignments of relevant organizations are as follows:
  - (1) ARC:  
ARC plays a role as an implementing agency. ARC will assign following personnel.
    - (a) Project Director  
Director General of ARC will be responsible for overall administration and implementation of the Project.
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Izzat Sidahmed Ali Tahir, Breeder of the Wheat Research Program of ARC will be responsible for implementation, managerial and technical matters of the Project.
    - (c) Research Group Leaders  
Research Group Leaders of ARC will be responsible for the implementation of the designated outputs referred in the PDM.
  - (2) Sudan Meteorological Authority (SMA):  
SMA will work closely with ARC for the output 4 of the Project in the PDM and provide necessary information on meteorology of Sudan.
  - (3) JICA experts:  
The JICA experts will give necessary technical guidance, advice and recommendations to ARC on any matters pertaining to the implementation of the Project.
3. Project duration:  
Five (5) years from the arrival of the first experts
4. Project sites and Beneficiaries:  
The main project site is ARC headquarter in Wad Medani. The Project will also implement the experimental cultivation of wheat at Hudeiba, Dongola and New Halfa. The direct beneficiaries of the Project are researchers of ARC, SMA and farmers.

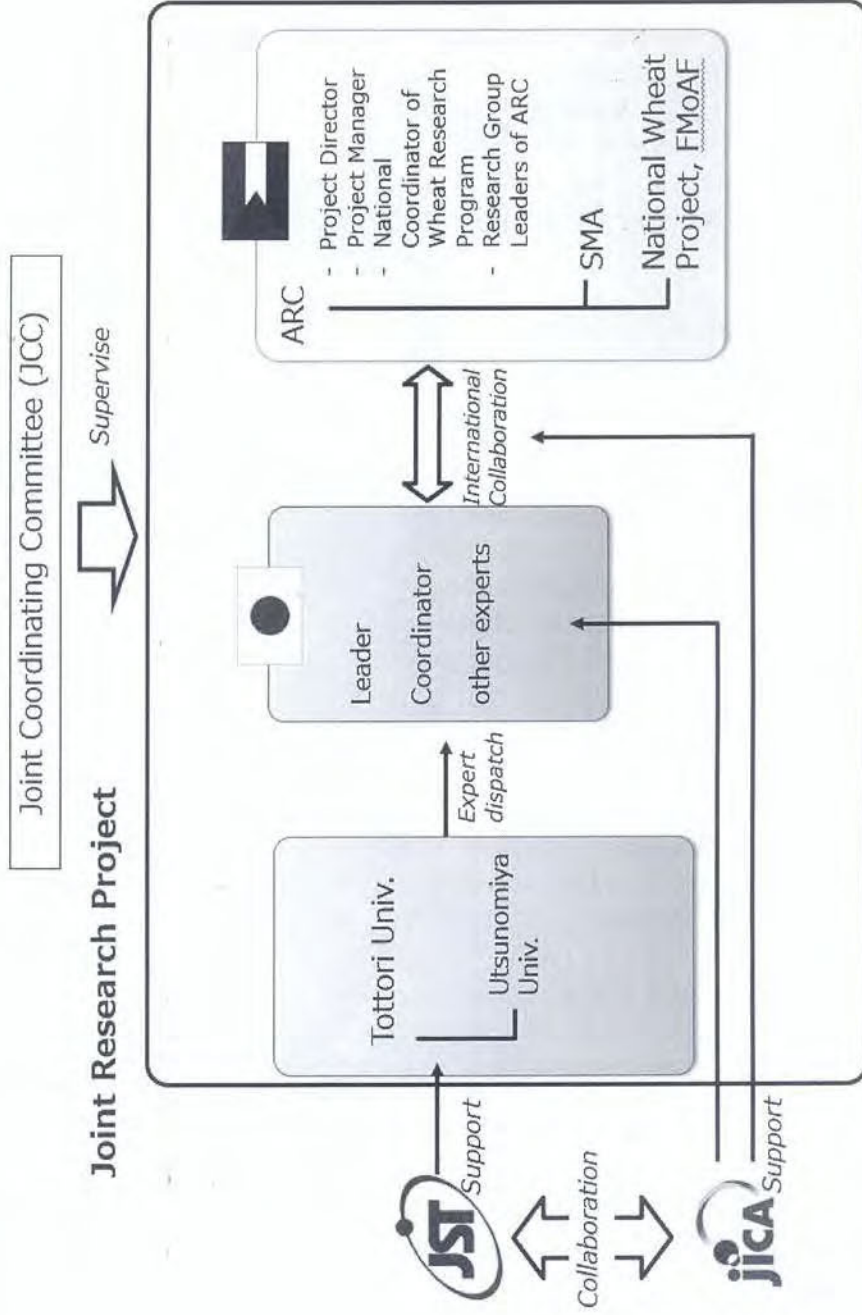
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5. Joint Coordination Committee  
Joint Coordinating Committee (hereinafter referred to as "JCC") will be established in order to facilitate inter-organizational coordination. JCC will be held at least once a year and whenever deems it necessary. JCC will review the progress, revise the overall plan when necessary, approve an annual work plan, conduct evaluation of the Project, and exchange opinions on major issues that arise during the implementation of the Project. A list of proposed members of JCC is shown in the Annex 5.
6. Exemption of tax and any other charges  
ARC will take necessary measures to exempt the JICA experts from taxes and any other charges on the equipment, machinery and other material necessary for the implementation of the Project, and to exempt the JICA experts from income tax and charges of any kind imposed on or in connection with any emoluments or allowances paid to them and/or remitted to them from abroad for their services in connection with the implementation of the Project.
7. Securing local component:  
ARC has a responsibility to secure the necessary local component for the smooth implementation of the Project.
8. Reports:  
ARC and JICA experts will jointly prepare the following documents.
  - Reports with monitoring sheets based on the Project Design Matrix (PDM) and Plan of Operation (PO) on semi-annual basis until the project completion. The format of the monitoring form is attached as Annex 6.
  - Project Completion Report at three (3) month before the completion of the Project.
9. Climate change (adaptation):  
The both sides acknowledge that this project contributes to enhancing adaptation measures to climate change in Sudan and Sub-Saharan Africa, since the project aims at developing climate change resilient wheat germplasm and the appropriate wheat production method.
10. Environmental and Social Considerations:  
With regard to the Section 10.1 of the BP, the Project is likely to have minimal adverse impact on the environment and society under the 'JICA Guidelines for Environmental and Social Considerations (April 2010)'.

END



Implementation Structure



3.

**List of Proposed Members of Joint Coordination Committee (JCC)**

JCC will be composed of the following members.

- (1) Chairperson
  - Project Director of ARC
  
- (2) Sudanese Side:
  - Project Director of ARC
  - Project Manager of ARC
  - National Coordinator of Wheat Research Program
  - Research Group Leaders of ARC
  - Director General of Sudan Meteorological Authority (SMA)
  - Coordinator of the National Wheat Production Project, Federal Ministry of Agriculture and Forests (FMoAF)
  - Director General, International Cooperation Directorate, Federal Ministry of Agriculture and Forests(FMoAF)
  
- (3) Japanese Side:
  - JICA Experts (including the Leader, Coordinator, and other experts)
  - Representative(s) of JICA
  
- (4) Observer:
  - Official(s) from the Embassy of Japan
  - Representative of Japan Science and Technology Agency (JST)
  - Other person(s) appointed by the Chairperson

## TO CR of JICA SUDAN OFFICE

## Project Monitoring Sheet

Project Title: \_\_\_\_\_

Version of the Sheet: Ver.●● (Term: Month, Year - Month, Year) \_\_\_\_\_

Name: \_\_\_\_\_

Title: Project Director \_\_\_\_\_

Name: \_\_\_\_\_

Title: Chief Advisor \_\_\_\_\_

Submission Date: \_\_\_\_\_

## I. Summary

**1 Progress**

1-1 Progress of Inputs

1-2 Progress of Activities

1-3 Achievement of Output

1-4 Achievement of the Project Purpose

1-5 Changes of Risks and Actions for Mitigation

1-6 Progress of Actions undertaken by JICA

1-7 Progress of Actions undertaken by Gov. of Sudan

1-8 Progress of Environmental and Social Considerations (if applicable)

1-9 Progress of Considerations on Gender/Peace Building/Poverty Reduction (if applicable)

1-10 Other remarkable/considerable issues related/affect to the project (such as other JICA's projects, activities of counterparts, other donors, private sectors, NGOs etc.)

**2 Delay of Work Schedule and/or Problems (if any)**

2-1 Detail

2-2 Cause

2-3 Action to be taken

2-4 Roles of Responsible Persons/Organization (JICA, Gov. of Sudan, etc.)

**3 Modification of the Project Implementation Plan**

3-1 PO

3-2 Other modifications on detailed implementation plan

*(Remarks: The amendment of R/D and PDM (title of the project, duration, project site(s), target group(s), implementation structure, overall goal, project purpose, outputs, activities, and input) should be authorized by JICA HDQs. If the project team deems it necessary to modify any part of R/D and PDM, the team may propose the draft.)*

**4 Current Activities of Gov. of Sudan to Secure Project Sustainability after its Completion**

## II. Project Monitoring Sheet I &amp; II as Attached



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## **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**

**The First Joint Coordination Committee (JCC) meeting, 1<sup>st</sup> March, 2020,**

**Agricultural Research Corporation Hall, Khartoum North, Shambat**

### **Minutes**

#### **Objectives:**

The objectives of this meeting are to revise and update the project design matrix (PDM), revise and update the plan of operation (PO), revise and approve the first-year activities plan, and check the project progress and other related issues.

#### **Attendance:**

The meeting was attended by almost all JCC members except the leaders of groups 2 & 3, the counterpart leader of group 4, and a representative of the DG, international Cooperation Directorate, Ministry of Agriculture and Natural Resources. (the attendance sheet is attached together with the list of JCC members).

#### **Program of Meeting and Remarks:**

##### **Opening remarks:**

##### **Director General, ARC**

The DG of ARC, Prof. Abdelmoneim Taha, gave the opening remarks and welcomed all committee members and observers. The DG also remarked on how ARC appreciates the assistance provided by this project to the Wheat Research Program of ARC., which will ultimately promote wheat production in Sudan and Africa. He stressed the readiness to support the fulfillment of this project's final goals and objectives since it has a tangible contribution to the agricultural research quality,

the capacity building of young scientists, and hopefully, the genetic improvement of the wheat crop considering the different stresses faced in Sudan and the development of a model and the contribution that could be done in sub-Saharan Africa.

### **Representative of JICA Office in Sudan:**

Mr. M. Takahashi, JICA country representative in Sudan addressed the meeting. His speech was focused on three points: the significance of the project's contribution to climate change, Sudan's food security, and spillover in Africa and other regions. The second point is the project's uniqueness compared to other SATREPS projects, mainly due to the strong relationship between the project's partners, which formed a strong foundation. The third point is the sustainability of the project outputs since it focuses on human resources and capacity building.

### **Director General, SMA**

Dr. Hanan expressed her belief in the importance of this project and its contribution to improving wheat production technologies considering climate change. The project has made an excellent contribution to the capacity building of the SMA staff. She also expressed their commitment to providing historical metrological data that contributes to the development of crop modeling scenarios.

### **Introduction of the Project and its objectives:**

Prof. Tsujimoto gave a short presentation as an introduction, giving information about what SATREPS is and who are the funding agencies (JICA & JST). He also gave an idea about the project's ultimate goal (Sustainable wheat production in hot, dry environments in Sudan and sub-Saharan Africa). He also gave a general idea about the project's direct objectives, emphasizing the breeding part and the search for novel genes in the new material used (MSD & LSD).

### **Project PDM, PO, and monitoring sheet:**

In this part, Dr. Izzat started by presenting a somewhat more detailed introduction about the project's design matrix (PMD) and the plan of operation (PO) based on the five groups of the project in terms of narrative summary, verifiable indicators, and means of verification.

Dr. Izzat has also given a good idea about the activities and timelines of the PO based on all five groups. The activities of first group 1 (**Breeding**) are nine activities starting at different times within the project duration (2018-2022), and they all end by 2024. The second group (**Quality**) stated that the activities are within 2019-20, while the finishing time varies from 2020 to 2023. As for the Physiology and Mechanism group (3), three activities were listed for execution within a time frame that started in 2019 and ended in 2023. Five activities were listed for the fourth group (**Climate Change**), with some starting in 2019, some will end in 2020, and others will end in 2022. Some activities for this group will start in 2021-22 and finish by 2023. Finally, the **Capacity Building** group (5) has a list of five activities that start between 2019 and 2021 and all end by 2023.

Dr. Izzat also gave insight into the contribution of both the Japanese (JICA & JST) and Sudanese sides in terms of finance, expertise, equipment, office space, and other facilities that would ensure the project's success. For instance, the Japanese side is contributing by an amount of 287 million JPY in terms of technical backstopping, machinery, and vehicles, establishing and equipping a molecular breeding laboratory and a speed breeding facility, degree and short-term training in addition to covering the cost of local activities of the different groups. The budget is complimented by an amount of 39.7 million SDG from the Sudanese (local component), which will cover the expenses of part of the operational and construction cost of the facilities, field operational expenses of the heat research platform, local capacity building, IT, customs, office supplies and local cost of travel, salaries, and perdium.

Dr. Izzat has also highlighted some preconditions and assumptions that would ensure the success and sustainability of the post-project activities, including the commitment of the ARC and the Sudanese government to provide all facilities that would help operate this project successfully.

Mr. Konaka, the project coordinator, listed the equipment purchased for FY2019 and the budget allocation plan for FY2020, which has 9.3 million JPY for management and maintenance. He also pinpointed the plan for construction and laboratory equipment in addition to the human resource development plan for degree training and short training.

## **Activities of the First Year:**

Dr. Yasir presented the activities and the timeline for the detailed activities of this first year for the four components as follows:

**Component 1:** A total of four major activities have already been initiated this season, 2019-2020:

1. Multi-environment evaluation is done for selection confirmation of the desired lines under different thermal regimes and water and nitrogen deficits.
2. Initiation of the development process for at least 3 RILs for heat tolerance, yield potential, and phosphorous utilization efficiency.
3. Initiation of the work on establishing a database for wheat important QTLs and markers for quality, rust resistance, and heat tolerance.
4. Initiation of evaluating 4-8 ABA hypersensitive lines selected from the MSD population under drought conditions and conduct QTL analysis.

**Component 2** mainly focuses on the enhancement of the nutritional value and end-use quality under heat-stressed environments, and to achieve these objectives, four activities are executed this season, which are:

1. Examination of seed characters and quality parameters focusing on seed hardness and shape as affected by heat stress, drought, and nitrogen deficiency.
2. Analysis of protein content and use end-use quality for 150 MSD lines affected by drought and nitrogen deficiency under Sudan and Japanese conditions. Another activity is analyzing protein content and end-use quality for 150 MSD lines + 70 elite genotypes under different thermal regimes.
3. Analysis of mineral content and nutritional value for the same lines as above under the same conditions.
4. Activities to introduce the high-quality gene in the genetic background of the Sudanese cultivars (Bohaine) using crossing and backcrossing and the development of RILs.

**Component 3** aims to understand the mechanisms behind tolerance to heat and water-deficit stress and those underlying improved utilization of the nutrients through 3 main activities:

1. Detailed physiological evaluation for 5-10 genotypes (sensitive + tolerant) under field and growth chamber conditions.
2. Analyze metabolites produced specifically in tolerant lines under stressed conditions (heat and drought) and identify the metabolites to reveal the tolerance mechanism for selection. Also, an activity was conducted to evaluate the metabolite profile for the 5-10 genotypes in the first activity of this component.
3. The third activity focuses on Identifying usable genes for selection from the profile of tolerant lines mRNA.

**Component 4** aims at developing wheat production scenarios in Sudan for future climate change and the generation of sustainable, environmentally friendly, and appropriate wheat production technologies. Three activities are ongoing to achieve this are as follows:

1. Predict the climate of Sudan in 2050 from the past and present climate observation and rising CO<sub>2</sub> concentration
2. Develop crop model for wheat production in different climate scenarios
3. Develop climate-smart agricultural crop production technologies (CSA)

**Component 5** is mainly focused on strengthening the capacity of researchers and farmers and enhancing interaction among different stakeholders for increased and sustainable wheat production. A total of five activities are ongoing in this component:

1. A preliminary survey was conducted to determine the Project intervention areas
2. Efforts to establish the project website and multimedia content for technology dissemination, communication, and awareness among the stakeholders
3. Ongoing degree training and non-degree training in Japan and Sudan
4. Breeder and pre-basic seed production for IP operation
5. Establishment of the speed breeding facility, which this year focused on establishing the new workstation facility, the preparation of the design, specifications, and company for the laboratory renovation and glass house construction, the preparation of the bidding for the consultation and construction companies, working on making contracts between Tottori

University and ARC and finally the decision on the company for the laboratory design and equipment procurement

Dr. Yassir, as a leader of group 5, also gave a detailed progress report on the activities to be achieved this year:

- Establish the new workstation facility
- Prepare the design, specifications, and company for the laboratory renovation and glass house construction
- Prepare bidding for the consultation and construction companies
- Make contracts between Tottori University and ARC
- Decide the company for the laboratory design and equipment procurement

Finally, Dr. Yassir has also presented the planned vs. actual timeline for the PDM and PO, which clearly showed some activities are ahead of schedule and others are delayed, which encouraged the suggestion of changing the timeline of execution of the planned activities to have maximum utilization of resources and time.

### **Discussion:**

Prof. Taha started the discussion on the breeding log frame, suggesting using “at least ten lines...” Instead of “10 lines...”. He also suggested putting the laboratory establishment and equipment within the capacity-building activities. Another suggestion is not to target researchers and farmers only but to include all stakeholders in the wheat value chain.

Dr. Hanan inquired about whether the budget is approved year by year or for the whole duration of the project. She also inquired about the number of Automatic Weather Stations and possibly increasing one station to four instead of three. She also inquired about the timeline to expect the servers within the SMA.

Dr. Yassir suggested opening the degree and non-degree training in Japan for all stakeholders in the wheat value chain rather than for the partners only. Dr. Yassir also suggested rearranging the timeline line due to the delayed budget opening for the project.

Prof. Tsujimoto suggested a logo for the project, and after discussion, the initial idea was approved. It was suggested that a professional designer get the final logo of the project.

### **Closing Remarks:**

The JICA representative was pleased to learn that some POs were executed this season despite the delayed budget release. He also approved the general idea of the project logo suggested by Prof. Tsujimoto, which insinuates that the dream of the project is to spread wheat to Africa from the Heart of Africa (Sudan)

Dr. Hanan of SMA expressed her thanks for the project and its contribution to the capacity building of SMA in terms of human resource development and the provision of AWS and powerful servers.

Prof. Taha, DG of ARC, has expressed his gratitude for the project and reinstated the commitment of the ARC and the Sudanese government to avail themselves of everything possible to facilitate the course of this project and its success and sustainability.

### **Recommendations:**

Finally, the meeting recommended:

1. The 1<sup>st</sup> week of September 2020 for the second JCC meeting.
2. Modify the timeline in the document and re-sign it to all partners to be approved, as well as the new document of the project.
3. The project logo is to be finalized with a professional designer.

### **Attachments:**

- JCC members list
- 1<sup>st</sup> meeting agenda
- Attendance sheet

**MINUTES OF MEETINGS  
BETWEEN  
AGRICULTURAL RESEARCH CORPORATION OF REPUBLIC OF SUDAN  
AND  
JAPAN INTERNATIONAL COOPERATION AGENCY  
FOR AMENDMENT OF THE RECORD OF DISCUSSIONS  
ON  
THE PROJECT  
FOR THE 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**

Agricultural Research Corporation of Sudan (hereinafter referred to as "ARC") and the Japan International Cooperation Agency (hereinafter referred to as "JICA") hereby agree that the Record of Discussions on the Project for the 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 signed on 4<sup>th</sup> February 2019 is amended as follows;

1. Annex1 Project Design Matrix (PDM)

Before	Amended Version
ACTIVITIES 5.6 Conduct degree trainings in Japan	ACTIVITIES 5.6 Conduct degree and non-degree trainings in Japan and Sudan
OBJECTIVELY VERIFIABLE INDICATORS 5.5 Ten (10) MSc or PhD degrees are obtained	OBJECTIVELY VERIFIABLE INDICATORS 5.5 Six (6) MSc or PhD degrees are obtained

2. Annex 2 Plan of Operation (PO)

Before	Amended Version
ACTIVITIES 5.6 Conduct degree trainings in Japan	ACTIVITIES 5.6 Conduct degree and non-degree trainings in Japan and Sudan

Reason: Based on the review of current situation and future plan, this amendment was proposed and agreed at the 2<sup>nd</sup> JCC meeting held on November 2020.

The parties acknowledge and agree that this Minutes of Meetings may be executed by electronic signature, which is considered as an original signature for all purposes and has the same force and effect as an original signature. "Electronic signature" includes faxed versions of an original signature or electronically scanned and transmitted versions (e.g., via pdf) of an original signature.

15

AM

This amendment will become effective as of the signed date.

Annex : Record of Discussions (signed on 4<sup>th</sup> February 2019)

Khartoum, 5 July, 2021



Mr. SAKANE Koji

Chief Representative  
Sudan Office  
Japan International Cooperation Agency



Professor. Abdelmonim Taha Ahmed

Director General  
Agricultural Research Corporation

**RECORD OF DISCUSSIONS**

**FOR**

**PROJECT FOR THE DEVELOPMENT OF CLIMATE CHANGE  
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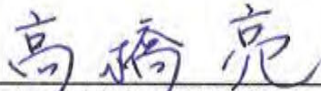
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3

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JAPAN INTERNATIONAL  
COOPERATION AGENCY



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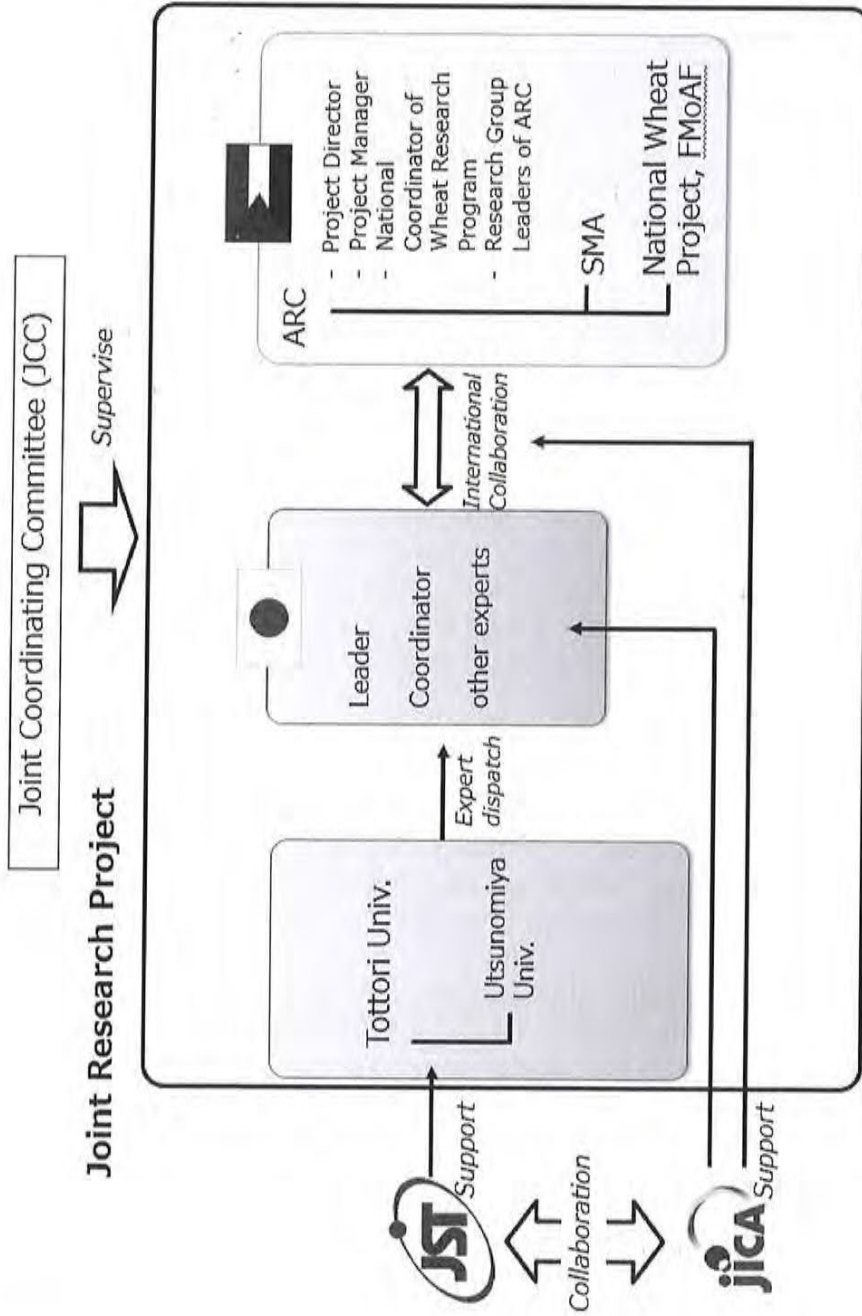


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ARC and JICA experts will jointly prepare the following documents.
  - Reports with monitoring sheets based on the Project Design Matrix (PDM) and Plan of Operation (PO) on semi-annual basis until the project completion. The format of the monitoring form is attached as Annex 6.
  - Project Completion Report at three (3) month before the completion of the Project.
9. Climate change (adaptation):  
The both sides acknowledge that this project contributes to enhancing adaptation measures to climate change in Sudan and Sub-Saharan Africa, since the project aims at developing climate change resilient wheat germplasm and the appropriate wheat production method.
10. Environmental and Social Considerations:  
With regard to the Section 10.1 of the BP, the Project is likely to have minimal adverse impact on the environment and society under the 'JICA Guidelines for Environmental and Social Considerations (April 2010)'.

END



Implementation Structure



**List of Proposed Members of Joint Coordination Committee (JCC)**

JCC will be composed of the following members.

- (1) Chairperson
  - Project Director of ARC
  
- (2) Sudanese Side:
  - Project Director of ARC
  - Project Manager of ARC
  - National Coordinator of Wheat Research Program
  - Research Group Leaders of ARC
  - Director General of Sudan Meteorological Authority (SMA)
  - Coordinator of the National Wheat Production Project, Federal Ministry of Agriculture and Forests (FMoAF)
  - Director General, International Cooperation Directorate, Federal Ministry of Agriculture and Forests(FMoAF)
  
- (3) Japanese Side:
  - JICA Experts (including the Leader, Coordinator, and other experts)
  - Representative(s) of JICA
  
- (4) Observer:
  - Official(s) from the Embassy of Japan
  - Representative of Japan Science and Technology Agency (JST)
  - Other person(s) appointed by the Chairperson

## TO CR of JICA SUDAN OFFICE

## Project Monitoring Sheet

Project Title: \_\_\_\_\_

Version of the Sheet: Ver.●● (Term: Month, Year - Month, Year) \_\_\_\_\_

Name: \_\_\_\_\_

Title: Project Director \_\_\_\_\_

Name: \_\_\_\_\_

Title: Chief Advisor \_\_\_\_\_

Submission Date: \_\_\_\_\_

## I. Summary

**1 Progress**

1-1 Progress of Inputs

1-2 Progress of Activities

1-3 Achievement of Output

1-4 Achievement of the Project Purpose

1-5 Changes of Risks and Actions for Mitigation

1-6 Progress of Actions undertaken by JICA

1-7 Progress of Actions undertaken by Gov. of Sudan

1-8 Progress of Environmental and Social Considerations (if applicable)

1-9 Progress of Considerations on Gender/Peace Building/Poverty Reduction (if applicable)

1-10 Other remarkable/considerable issues related/affect to the project (such as other JICA's projects, activities of counterparts, other donors, private sectors, NGOs etc.)

**2 Delay of Work Schedule and/or Problems (if any)**

2-1 Detail

2-2 Cause

2-3 Action to be taken

2-4 Roles of Responsible Persons/Organization (JICA, Gov. of Sudan, etc.)

**3 Modification of the Project Implementation Plan**

3-1 PO

3-2 Other modifications on detailed implementation plan

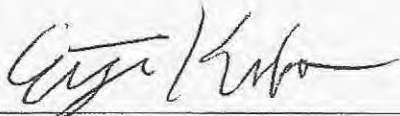
*(Remarks: The amendment of R/D and PDM (title of the project, duration, project site(s), target group(s), implementation structure, overall goal, project purpose, outputs, activities, and input) should be authorized by JICA HDQs. If the project team deems it necessary to modify any part of R/D and PDM, the team may propose the draft.)*

**4 Current Activities of Gov. of Sudan to Secure Project Sustainability after its Completion**II. Project Monitoring Sheet I & II *as Attached*

**MINUTES OF MEETINGS  
BETWEEN  
AGRICULTURAL RESEARCH CORPORATION OF THE REPUBLIC OF THE  
SUDAN  
AND  
JAPAN INTERNATIONAL COOPERATION AGENCY  
FOR AMENDMENT OF THE RECORD OF DISCUSSIONS  
ON  
THE PROJECT FOR THE 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**

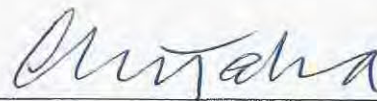
Agricultural Research Corporation (hereinafter referred to as "ARC") and Japan International Cooperation Agency (hereinafter referred to as "JICA") conducted the 4<sup>th</sup> Joint Coordination Committee (hereinafter referred to as "JCC") in October 26<sup>th</sup>, 2022 with all stakeholders of the Project for the 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 (hereinafter referred to as "the Project"). As a result, both sides have reached a mutual understanding and the Record of Discussions on the Project will be amended as attached.

Khartoum, 8 August, 2023



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Mr. Eiji Kubo  
Chief Representative  
Sudan office  
Japan International Cooperation Agency



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Professor. Abdelmoneim Taha Ahmed  
Director General  
Agricultural Research Corporation

1. Annex 1 Logical Framework (Project Design Matrix: PDM) / Annex 2 Tentative Plan of Operation

Before	Amended Version
Indicator for Overall Goal	
Two (2) or three (3) new candidate varieties are developed	At least two (2) new candidate varieties are developed
Indicator for Output 3.1	
Two (2) or three (3) mechanisms behind heat and water-deficit stress tolerance, and better utilization of nutrients are clarified and information are made available	At least two (2) mechanisms behind heat and water-deficit stress tolerance, and better utilization of nutrients are clarified and information are made available
Indicator for Output 5.4	
The xx viewers of the contents provided by the Project are reached	Fifteen thousand (15,000) people view the contents of the web site and the multimedia provided by the Project
Activity 1.7	
Produce officially categorized seeds	Produce early generation seeds (breeder and pre-basic seeds)
Activity 4.3	
Analyze the economic impact of the wheat production on the national economy in different climate scenario.	Deleted Reason: It is difficult to conduct the economic analysis under the current economic situation in Sudan

2. R/D amendment procedure

- (1) To allow for more flexible project implementation based on the revised R/D amendment procedure, both parties agreed that the contents of Annex 2 to 5 of the revised R/D might be modified by mutual confirmation such as the finalization of Monitoring Sheets or the Minutes of Meetings to be concluded at the Joint Coordinating Committee. However, in case of revising the contents mentioned in Annex 6: Project Description, a Minute of Meeting for revising R/D shall be signed.
- (2) To reflect the above, the paragraph 5 of the main part of R/D (Annex 8) shall be changed as follows.

Before	Amended Version
The R/D may be amended by minutes of meetings between both parties, except the plan of operation to be modified in monitoring sheet. The minutes of meetings will be signed by authorized persons of each side who	The R/D may be amended by minutes of meetings between both parties, except <u>Annex 2 to 5</u> to be modified by <u>minutes of meetings between both parties</u> . The minutes of meetings will be signed by authorized persons of each side who may be different from

<p>may be different from the signers of the R/D.</p> <p>[Annex]  Annex 1 Main Points Discussed  Annex 2 Project Design Matrix (PDM)  Annex 3 Plan of Operation (PO)  Annex 4 Implementation Structure  Annex 5 List of Proposed Members of Joint Coordinating Committee</p>	<p>the signers of the R/D.</p> <p>[Annex]  Annex 1: Main Points Discussed  <u>Annex 2: Project Design Matrix (PDM)</u>  <u>Annex 3: Plan of Operation (PO)</u>  Annex 4: Project Implementation Structure  <u>Annex 5: List of Joint Coordinating Committee (JCC) Members</u>  <u>Annex 6: Project Description</u>  <u>Annex 7 : Amended Record of Discussions (signed 5<sup>th</sup> July, 2021)</u>  <u>Annex 8: Record of Discussions (signed 4<sup>th</sup> Feb, 2019)</u></p>
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- Annex 1: Main Points Discussed
- Annex 2: Project Design Matrix (PDM)
- Annex 3: Plan of Operation (PO)
- Annex 4: Project Implementation Structure
- Annex 5: List of Joint Coordinating Committee (JCC) Members
- Annex 6: Project Description
- Annex 7 : Amended Record of Discussions (signed 5<sup>th</sup> July, 2021)
- Annex 8 : Record of Discussions (signed 4<sup>th</sup> Feb, 2019)

- Appendix 1 : Main Points Discussed on the 4<sup>th</sup> JCC
- Appendix 2 : Revised Project Management Structure
- Appendix 3 : Participants List

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## MAIN POINTS DISCUSSED

1. The program under which the Project is implemented:  
Both sides noted that the Project is implemented under the Science and Technology Research Partnership for Sustainable Development (hereinafter referred to as "SATREPS") program, promoted by JICA and Japan Science and Technology Agency (JST) in collaboration. SATREPS aims to develop new technologies and their applications for tackling global issues, and also aims at capacity development of researchers and research institutes in both countries.
2. Implementation Structure:  
The project organization chart is given in the Annex 4. The roles and assignments of relevant organizations are as follows:
  - (1) ARC:  
ARC plays a role as an implementing agency. ARC will assign following personnel.
    - (a) Project Director  
Director General of ARC will be responsible for overall administration and implementation of the Project.
    - (b) Project Manager  
Izzat Sidahmed Ali Tahir, Breeder of the Wheat Research Program of ARC will be responsible for implementation, managerial and technical matters of the Project.
    - (c) Research Group Leaders  
Research Group Leaders of ARC will be responsible for the implementation of the designated outputs referred in the PDM.
  - (2) Sudan Meteorological Authority (SMA):  
SMA will work closely with ARC for the output 4 of the Project in the PDM and provide necessary information on meteorology of Sudan.
  - (3) JICA experts:  
The JICA experts will give necessary technical guidance, advice and recommendations to ARC on any matters pertaining to the implementation of the Project.
3. Project duration:  
Five (5) years from the arrival of the first experts
4. Project sites and Beneficiaries:  
The main project site is ARC headquarter in Wad Medani. The Project will also implement the experimental cultivation of wheat at Hudeiba, Dongola and New Halfa. The direct beneficiaries of the Project are researchers of ARC, SMA and farmers.

5. Joint Coordination Committee  
Joint Coordinating Committee (hereinafter referred to as "JCC") will be established in order to facilitate inter-organizational coordination. JCC will be held at least once a year and whenever deems it necessary. JCC will review the progress, revise the overall plan when necessary, approve an annual work plan, conduct evaluation of the Project, and exchange opinions on major issues that arise during the implementation of the Project. A list of proposed members of JCC is shown in the Annex 5.
6. Exemption of tax and any other charges  
ARC will take necessary measures to exempt the JICA experts from taxes and any other charges on the equipment, machinery and other material necessary for the implementation of the Project, and to exempt the JICA experts from income tax and charges of any kind imposed on or in connection with any emoluments or allowances paid to them and/or remitted to them from abroad for their services in connection with the implementation of the Project.
7. Securing local component:  
ARC has a responsibility to secure the necessary local component for the smooth implementation of the Project.
8. Reports:  
ARC and JICA experts will jointly prepare the following documents.
  - Reports with monitoring sheets based on the Project Design Matrix (PDM) and Plan of Operation (PO) on semi-annual basis until the project completion. The format of the monitoring form is attached as Annex 6.
  - Project Completion Report at three (3) month before the completion of the Project.
9. Climate change (adaptation):  
The both sides acknowledge that this project contributes to enhancing adaptation measures to climate change in Sudan and Sub-Saharan Africa, since the project aims at developing climate change resilient wheat germplasm and the appropriate wheat production method.
10. Environmental and Social Considerations:  
With regard to the Section 10.1 of the BP, the Project is likely to have minimal adverse impact on the environment and society under the 'JICA Guidelines for Environmental and Social Considerations (April 2010)'.

END

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Aty



	The Japanese side	The Sudanese side	
<p>ation evaluation for selection and confirmation of the desired ment of QTLs for each of the desired traits, genotyping and leadon ment of PCR markers for the identified QTLs minating in the background of N61 and Sudanese cultivar ing establish MAS to transfer the desired QTLs to Sudanese e background as registration early generation seeds (breeder and pre-basic seeds) e future breeding strategies based on climate analysis output n of ABA hyper-sensitive line for drought tolerance and QTL.</p>	<ol style="list-style-type: none"> <li>1. Allocation of the Japanese experts</li> <li>2. Machinery and Vehicle procurement and maintenance</li> <li>3. Establish molecular and speed breeding facility</li> <li>4. Equipments for molecular and speed breeding</li> <li>5. Twenty-five (25) Short and medium-term specialized training in Japan and Sudan for Project counterparts and other IP stakeholders</li> <li>6. Local cost for the activities for the different activities of the Project</li> </ol>	<ol style="list-style-type: none"> <li>1. Allocation of the counterpart personnel</li> <li>2. Provision of offices and necessary space for the Japanese experts</li> <li>3. Local cost (salary of the personnel, utilization of existing machinery and equipment, maintenance and running cost of the machinery)</li> <li>4. Provision of postgraduate degree assistantship in local universities</li> <li>5. Provision of experimental farms and laboratory space at all sites</li> </ol>	<ul style="list-style-type: none"> <li>- Electricity, Water, Basic Infrastructure, Materials necessary for the experiments (reagents, chemicals, samples in the processing of mRNA to cDNA in the molecular genetics study) are available</li> </ul>
<p>1. The seed characters and quality parameters of lines grown ed stress conditions s of protein content and bread making quality s of the mineral contents and nutritional value e lines which possess the desired traits with the N61 and lives to identify the QTLs and develop molecular markers for e the high quality gene (Glu D1d) to the genetic background of ultivar (Abinica) that maintain high bread making quality even temperature</p>	<ol style="list-style-type: none"> <li>1. Physiological evaluation for the tolerant and sensitive lines in growth chambers</li> <li>2. metabolites produced specifically in tolerant lines under dition and identify the metabolites to reveal the mechanism of 2 to be used for selection</li> <li>3. genes usable for selection from the profile of tolerant lines</li> </ol>		<p><b>Pre-Conditions</b></p> <ul style="list-style-type: none"> <li>- The vision and the mission of the ARC and Sudan government strategic plan to increase wheat production and realize self-sufficiency will be continued</li> <li>- Before the commencement of the project, ARC will finish to relocate the staff and to hand over the facility which supposed to be used as the breeding laboratory after renovation.</li> <li>- ARC secures the local component for this project to develop new wheat varieties in a continuous way.</li> <li>- Public security and political situation are not drastically deteriorated</li> <li>- Climate condition is not drastically changed</li> </ul>
<p>the climate of Sudan in 2050 from the past and present climate and rising CO2 concentration n crop model for wheat production in different climate scenarios e the response of the developed germplasm to the future climate n climate smart agricultural crop production technologies (CSN)</p>			
<p>it base line survey to determine the Project intervention areas at a monitoring and impact assessment studies e officially categorized seeds in Project website, multimedia contents for technology on, communication and awareness among the stakeholders th innovation platform for all stakeholders among the wheat n degree and 2015 degree trainings in Japan and Sudan</p>			



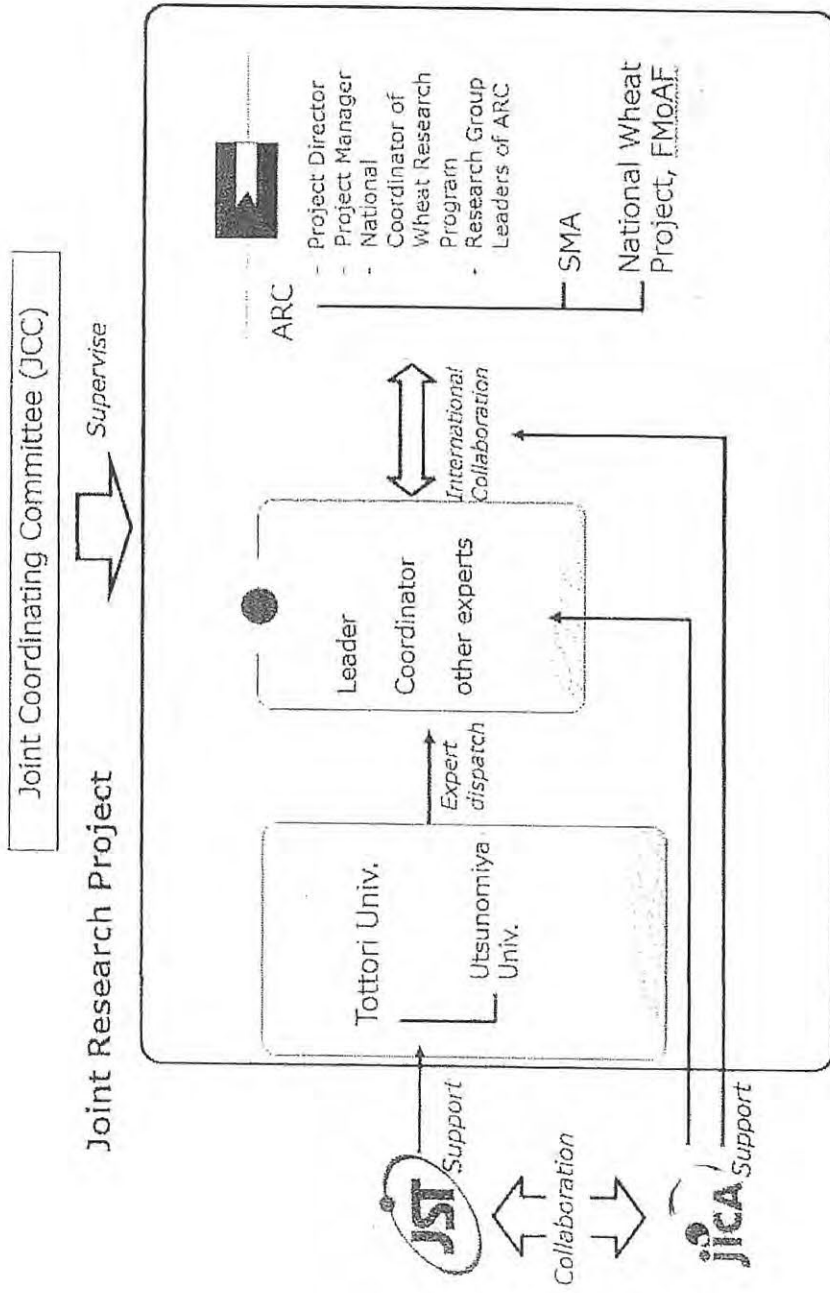
Activity	Nutritional value and end use quality of wheat are enhanced under the heat-stressed environments of Sudan	2019		2020		2021		2022		2023		2024		Issue	Solution	
		I	II	III	IV	I	II	III	IV	I	II	III	IV			
ut 2:	2.1. Examine the seed characters and quality parameters of lines grown under heat and stress conditions 2.2. Analysis of protein content and bread making quality 2.3. Analysis of the mineral contents and nutritional value 2.4. Cross the lines possess the desired traits with the NE1 and Sudanese cultivars to identify the QTLs and develop molecular markers for MAS 2.5. Introduce the high quality gene (Glu-D1d) to the genetic background of a Sudanese cultivar (Bohain) that maintain high BMQ even under high temperature Mechanisms behind heat and water-deficit stress tolerance, and better utilization of nutrients are clarified and information is made available to be utilized in future breeding strategies	Plan														
		Actual														
		Plan														
		Actual														
		Plan														
		Actual														
		Plan														
		Actual														
		Plan														
		Actual														
		Plan														
		Actual														
ut 3:	3.1. Detailed physiological evaluation for the tolerant and sensitive lines in the field and growth chambers 3.2. Analyze metabolites produced specifically in tolerant lines under stressed condition and identify the metabolites to reveal the mechanism of the tolerance and to be used for selection 3.3. Identify genes usable for selection from the profile of tolerant lines mRNA Sustainable, environmentally-friendly and appropriate crop production technologies and innovations are developed	Plan														
		Actual														
		Plan														
		Actual														
		Plan														
		Actual														
		Plan														
		Actual														
		Plan														
		Actual														
		Plan														
		Actual														
ut 4:	4.1. Predict the climate of Sudan in 2050 from the past and present climate observation and using CO2 concentration 4.2. Develop crop model for wheat production in different climate scenarios 4.3. Examine the response of the developed germplasm to the future climate scenarios 4.4. Develop climate smart agricultural crop production technologies (CSA) Capacity of researchers and farmers are strengthened and interaction among different stakeholders are enhanced for increased and sustainable wheat production	Plan														
		Actual														
		Plan														
		Actual														
		Plan														
		Actual														
		Plan														
		Actual														
		Plan														
		Actual														
		Plan														
		Actual														
ut 5:	5.1. Conduct base line survey to determine the project intervention areas 5.2. Conduct a monitoring and impact assessment 5.3. Produce officially categorized seeds 5.4. Establish project website, multimedia contents for technology dissemination, organization, and awareness among the stakeholders 5.5. Establish innovation platform for all stakeholders among the wheat value chain 5.6. Conduct degree and non-degree trainings in Japan and Sudan	Plan														
		Actual														
		Plan														
		Actual														
		Plan														
		Actual														
		Plan														
		Actual														
		Plan														
		Actual														
		Plan														
		Actual														

Activity	Monitoring Plan	2019		2020		2021		2022		2023		2024		Issue	Solution
		I	II	III	IV	I	II	III	IV	I	II	III	IV		
Monitoring	Joint Coordinating Committee Submission of Monitoring Sheet Monitoring Mission from Japan Reports/Documents Project Completion Report ic Relations To be determined	Plan													
		Actual													
		Plan													
		Actual													

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Implementation Structure

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**List of Joint Coordination Committee (JCC) Members**

JCC will be composed of the following members.

(1) Chairperson

- Project Director of ARC

(2) Sudanese Side:

- Project Director of ARC
- Project Manager of ARC
- National Coordinator of Wheat Research Program
- Research Group Leaders of ARC
- Director General of Sudan Meteorological Authority (SMA)
- Coordinator of the National Wheat Production Project, Federal Ministry of Agriculture and Forests (FMoAF)

(3) Japanese Side:

- JICA Experts (including the Leader, Coordinator, and other experts)
- Representative(s) of JICA

(4) Observer:

- Official(s) from the Embassy of Japan
- Representative of Japan Science and Technology Agency (JST)
- Other person(s) appointed by the Chairperson

*n*

*any*

### Project Description

- (1) Title of the Project  
Project for 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.
- (2) Overall Goal  
Climate change resilient and nutritious candidate wheat varieties are newly developed by ARC.
- (3) Project Purpose  
Climate change resilient and nutritious wheat germplasm and the appropriate wheat production method are developed, and that information is shared with the people concerned with the wheat production.
- (4) Period of the Project  
November, 2019 to November, 2024
- (5) Implementing Agency  
Agricultural Research Corporation (ARC)  
Sudan Metrological Authority (SMA)
- (6) Project Inputs (Japanese side, any important inputs)
  1. Allocation of the Japanese experts
  2. Machinery and Vehicle procurement and maintenance
  3. Establish molecular and speed breeding facility
  4. Equipment's for molecular and speed breeding
  5. Twenty-Five (25) Short and medium-term specialized trainings in Japan and Sudan for Project counterparts and other IP stakeholders
  6. Local cost for the activities for the different activities of the Project
- (7) Environmental and Social Considerations (A/B/C) : C  
The Project is likely to have minimal adverse impact on the environment and society under the "JICA Guidelines for Environmental and Social Considerations (April 2010)"

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**MINUTES OF MEETINGS  
BETWEEN  
AGRICULTURAL RESEARCH CORPORATION OF REPUBLIC OF SUDAN  
AND  
JAPAN INTERNATIONAL COOPERATION AGENCY  
FOR AMENDMENT OF THE RECORD OF DISCUSSIONS  
ON  
THE PROJECT  
FOR THE 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**

Agricultural Research Corporation of Sudan (hereinafter referred to as "ARC") and the Japan International Cooperation Agency (hereinafter referred to as "JICA") hereby agree that the Record of Discussions on the Project for the 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 signed on 4<sup>th</sup> February 2019 is amended as follows;.

1. Annex1 Project Design Matrix (PDM)

Before	Amended Version
ACTIVITIES 5.6 Conduct degree trainings in Japan	ACTIVITIES 5.6 Conduct degree and non-degree trainings in Japan and Sudan
OBJECTIVELY VERIFIABLE INDICATORS 5.5 Ten (10) MSc or PhD degrees are obtained	OBJECTIVELY VERIFIABLE INDICATORS 5.5 Six (6) MSc or PhD degrees are obtained

2. Annex 2 Plan of Operation (PO)

Before	Amended Version
ACTIVITIES 5.6 Conduct degree trainings in Japan	ACTIVITIES 5.6 Conduct degree and non-degree trainings in Japan and Sudan

Reason: Based on the review of current situation and future plan, this amendment was proposed and agreed at the 2<sup>nd</sup> JCC meeting held on November 2020.

The parties acknowledge and agree that this Minutes of Meetings may be executed by electronic signature, which is considered as an original signature for all purposes and has the same force and effect as an original signature. "Electronic signature" includes faxed versions of an original signature or electronically scanned and transmitted versions (e.g., via pdf) of an original signature.

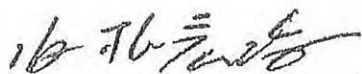
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This amendment will become effective as of the signed date.

Annex : Record of Discussions (signed on 4<sup>th</sup> February 2019)

Khartoum, 5 July, 2021



Mr. SAKANE Koji

Chief Representative  
Sudan Office  
Japan International Cooperation Agency



Professor. Abdelmonim Taha Ahmed

Director General  
Agricultural Research Corporation



RECORD OF DISCUSSIONS

FOR

PROJECT FOR THE 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

AGREED UPON BETWEEN

AGRICULTURAL RESEARCH CORPORATION

OF

REPUBLIC OF SUDAN

AND

JAPAN INTERNATIONAL COOPERATION AGENCY

Dated February 4 2019



Based on the minutes of meetings on the Detailed Planning Survey for the Project for the 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 (hereinafter referred to as "the Project") signed on 10 September 2018 between Agricultural Research Corporation of Sudan (hereinafter referred to as "the Counterpart") and the Japan International Cooperation Agency (hereinafter referred to as "JICA"), JICA held a series of discussions with the Counterpart and relevant organizations to develop a detailed plan of the Project.

The purpose of this record of discussions (hereinafter referred to as "the R/D") is to establish a mutual agreement for its implementation by both parties and to agree on the detailed plan of the Project as described in the followings and the Annexes, which will be implemented within the framework of the Note Verbales exchanged on 23 October 2018 between the Government of Japan and the Government of Sudan.

The Counterpart will be responsible for the implementation of the Project in cooperation with JICA, coordinate with other relevant organizations and ensure that the self-reliant operation of the Project is sustained during and after the implementation period in order to contribute toward social and economic development of Sudan.

Both parties also agreed that the Project will be implemented in accordance with the "Basic Principles for Technical Cooperation" published in December 2016 (hereinafter referred to as "the BP") attached as Annex 7, unless other arrangements are agreed in the R/D.

The R/D is delivered at Khartoum as of the day and year first above written. The R/D may be amended by a minutes of meetings between both parties, except the plan of operation to be modified in monitoring sheets. The minutes of meetings will be signed by authorized persons of each side who may be different from the signers of the R/D.

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### Main Points Discussed on the 4<sup>th</sup> JCC

The following items were discussed during the 4<sup>th</sup> JCC on October 26, 2022 and both the Sudan and Japanese sides agreed to take necessary actions accordingly.

#### 【Revision of PDM】

- Both sides confirmed the revised Project Design Matrix (hereinafter referred to as "PDM") in Annex 2 and the Plan of Operation (hereinafter referred to as "PO") in Annex 3 as follows:

Before	Amended Version
Indicator for Overall Goal	
Two (2) or three (3) new candidate varieties are developed	At least two (2) new candidate varieties are developed
Indicator for Output 3.1	
Two (2) or three (3) mechanisms behind heat and water-deficit stress tolerance, and better utilization of nutrients are clarified and information are made available	At least two (2) mechanisms behind heat and water-deficit stress tolerance, and better utilization of nutrients are clarified and information are made available
Indicator for Output 5.4	
The xx viewers of the contents provided by the Project are reached	Fifteen thousand (15,000) people view the contents of the web site and the multimedia provided by the Project
Activity 1.7	
Produce officially categorized seeds	Produce early generation seeds (breeder and pre-basic seeds)
Activity 4.3	
Analyze the economic impact of the wheat production on the national economy in different climate scenario.	Deleted Reason: It is difficult to conduct the economic analysis under the current economic situation in Sudan

#### 【Structural changes in project management】 (see Appendix 2)

- Prof. Hisashi Tsujimoto from Tottori University explained that Prof. Izzat, a project manager, moved to Japan and will stay one year from October 2022 as a visiting Professor of Tottori Univ. Both sides confirmed that Prof. Izzat will continue the project management remotely and Dr. Abusefyan Saad will be the Project Sub-Leader in Sudan side to follow up on activities and researches in Sudan.
- Both sides agreed that Prof. Tanaka (Group 2 leader) will be appointed as Project Sub-Leader in Japan side.

4. Both sides agreed that Dr. Abuelgasim Musa from Sudan Metrological Authority (hereinafter referred to as SMA) will be appointed as Group 4 Leader in Sudan side instead of Dr. Imad, who already left ARC.

#### **【Publicity Activities】**

5. Regarding the publicity activities of the project, due to the political turmoil in October 2021, JICA has requested all the projects to refrain from media exposure and PR activities to prevent JICA and our projects being exploited for political purpose, especially by the military. However, considering the current political and security situation in Sudan, both sides agreed that there would be no concern if the publicity was for "technology dissemination" and that the project would proceed with its dissemination as long as there was no concern of political use.

#### **【Laboratory Rehabilitation】**

6. Regarding the contract for the lab rehabilitation, JICA explained that the bidding price was higher than the predetermined price and need adjustment to budget and scope of work. On the other hand, the contract needs to be concluded within the remaining two months, by January 5<sup>th</sup>, 2023, due to the regulation of Ministry of Finance and Economic Planning (hereinafter referred to as MOFEP). Therefore, JICA requested the project to expedite the procedures for conclusion of the contract as soon as possible. ARC took note of it and explained that the contract is currently being drafted and will be signed within the stipulated time period, and that they are in discussions with MOFEP regarding customs exemptions, which may reduce the contract amount.

#### **【Local component】**

7. JICA shared the concerns regarding the sustainability of the project after the project completion due to delay in disbursement of the local component from MOFEP to ARC. JICA requests ARC to take necessary actions and formulate management structure for securing the annual budget, and ARC agreed. They also explained that regarding the fiscal year for Sudan 2022, they have been taking necessary measures and MOFEP already approved the budget, although not all of the approved amount is distributed due to current financial situation. JICA proposed to provide support for ARC for negotiation with MOFEP if necessary.

#### **【Intellectual Property Rights】**

8. JICA requested the project to consider the protection of intellectual property rights because the new wheat varieties are the result of joint research of the project and



many businesses are looking for new technologies in this field in the current situation of global food shortages. ARC took note of it and explained that the ARC has a lot of experience in seed variety registration and that all varieties in Sudan released by ARC are registered under the ARC and cannot be owned by any company.

**【Other】**

9. Both sides agreed that from the next JCC, all documents will be shared with the participants before the date of JCC in advance.

10. R/D amendment procedure

(1) To allow for more flexible project implementation based on the revised R/D amendment procedure, both parties agreed that the contents of Annex 2 to 5 of the revised R/D might be modified by mutual confirmation such as the finalization of Monitoring Sheets or the Minutes of Meetings to be concluded at the Joint Coordinating Committee. However, in case of revising the contents mentioned in Annex 6: Project Description, a Minute of Meeting for revising R/D shall be signed.

(2) To reflect the above, the paragraph 5 of the main part of R/D (signed 4<sup>th</sup> Feb 2019) shall be changed as follows.

Before	Amended Version
<p>The R/D may be amended by minutes of meetings between both parties, except the plan of operation to be modified in monitoring sheet. The minutes of meetings will be signed by authorized persons of each side who may be different from the signers of the R/D.</p>	<p>The R/D may be amended by minutes of meetings between both parties, except <u>Annex 2 to 5 to be modified by minutes of meetings between both parties.</u> The minutes of meetings will be signed by authorized persons of each side who may be different from the signers of the R/D.</p>
<p>[Annex] Annex 1 Main Points Discussed Annex 2 Project Design Matrix (PDM) Annex 3 Plan of Operation (PO) Annex 4 Implementation Structure Annex 5 List of Proposed Members of Joint Coordinating Committee</p>	<p>[Annex] Annex 1: Main Points Discussed Annex 2: Project Design Matrix (PDM) Annex 3: Plan of Operation (PO) Annex 4: Project Implementation Structure Annex 5: List of Joint Coordinating Committee (JCC) Members Annex 6: Project Description</p>

END.

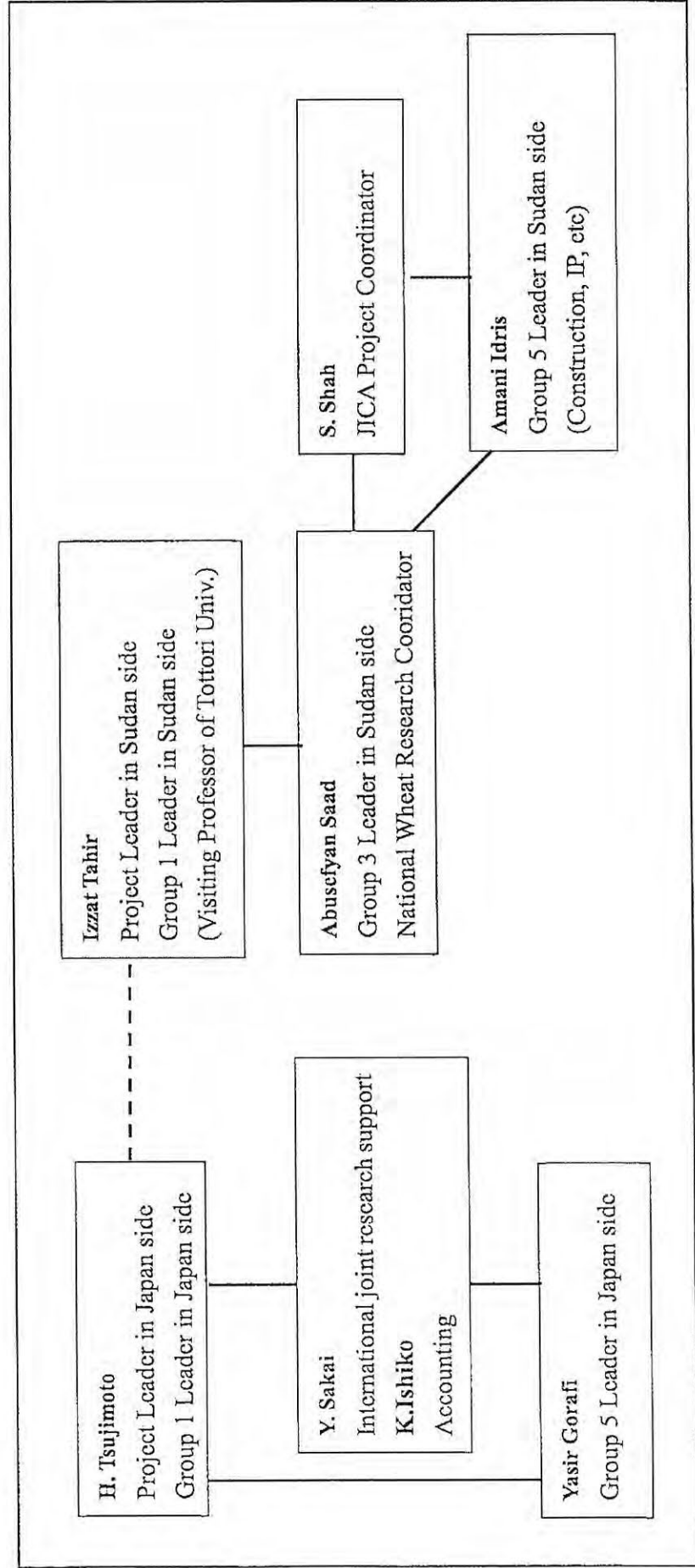


2

# Structural Change in Project Management

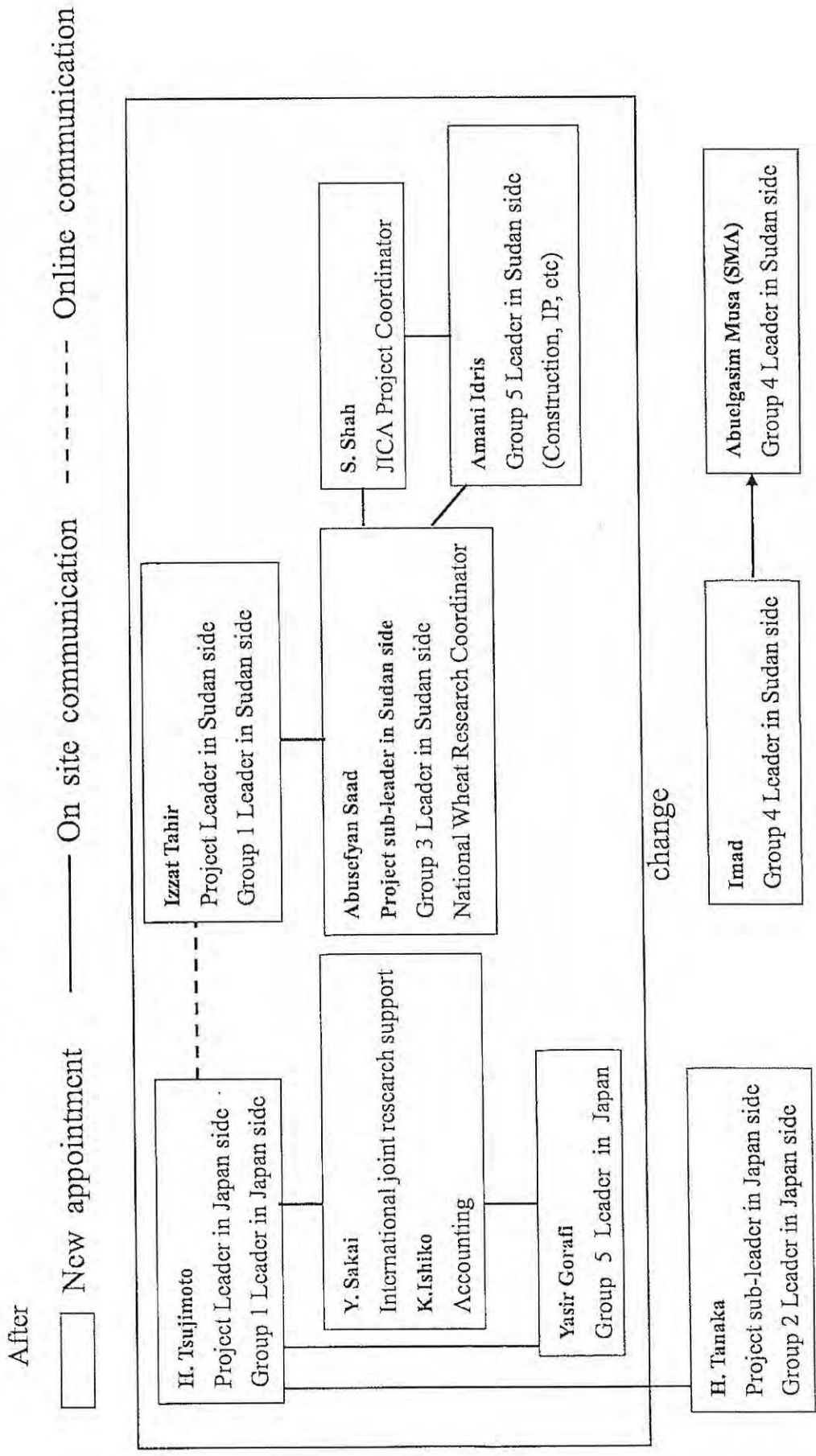
Before

—— On site communication      - - - - - Online communication



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# Structural Change in Project Management



## Participants list of 4th JCC

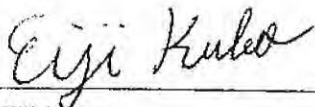
Organization	Position	Name
Project side		
Sudanese side		
ARC	Director General	Prof. Abdelmoneim Taha
	Deputy DG	Prof. Dafalla Ahmed Dawoud
	Project Leader, Wheat Breeder	Prof. Izzat Tahir
	Project CP, National Wheat Coordinator	Dr. Abusefian Ibrahim Saad
	Project CP	Dr. Amani Idris
SMA	Project CP	Dr. Hala Mohamed Mustafa
	Director General	Dr. Hanan Rabah
	Project CP	Dr. Abuelgasim I. Musa
Min. Agriculture	Wheat Coordinator Office	Ms. Mai Hassan
Japanese side		
Tottori Univ.	Project Leader, Director of Arid Land Research Center	Prof. Hisashi Tsujimoto
	Project, Faculty of Agricultur	Prof. Kinya Akashi
	Project, ALRC	Prof. Mitsuru Tsubo
	Project, Faculty of Agricultur	Dr. Hiroyuki Tanaka
	Project, ALRC	Dr. Yasir Gorafi
	Project, ALRC	Ms. Yumi Sakai
Utsunomia Univ.	Project, Center for Bioscience Research and Education	Dr. Masanori Okamoto
Project team	Project Coordinator	Dr. Takafumi Konaka
	Project Secretary	Ms. Julia Ibrahim Hussein
JICA		
Sudan office	Chief Representative	Mr. Koji Sakane
	Senior Representative	Ms. Yumi Kimura
	Assistant Representative	Mr. Hiroto Tsukada
	Program officer	Ms. Omnia Ali Ahmed
HQ	Economic Development Department Agricultural and Rural Development Group 2 Team 4	Ms. Yuriko Fukauchi
Observer		
Embassy of Japan	First Secretary	Mr. Minoru Yamaguchi
JST	Research Supervisor	Dr. Tsukasa Nagamine
	Associate Research Supervisor	Mr. Naoaki Furukawa
MOFEP Sudan	Bilateral Cooperation	Ms. Hanadi Hassan Mohammed Osman
	Sectoral Department	Ms. Rabaaea Awadelseed Elebeed

**MINUTES OF MEETINGS  
BETWEEN  
AGRICULTURAL RESEARCH CORPORATION OF THE REPUBLIC OF  
SUDAN  
AND  
JAPAN INTERNATIONAL COOPERATION AGENCY  
FOR AMENDMENT OF THE RECORD OF DISCUSSIONS  
ON  
THE PROJECT FOR THE 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**

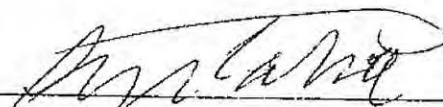
Agricultural Research Corporation (hereinafter referred to as "ARC") and Japan International Cooperation Agency (hereinafter referred to as "JICA") conducted the 5th Joint Coordination Committee (hereinafter referred to as "JCC") in November 1<sup>st</sup>, 2023 with all stakeholders of the Project for the 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 (hereinafter referred to as "the Project").

As a result of the discussion in the meeting, both parties agreed the matters (reached the consensus) referred to in the document attached hereto.

November 30th, 2023



Mr. Eiji Kubo  
Chief Representative  
Sudan office  
Japan International Cooperation Agency



Professor. Abdelmoneim Taha Ahmed  
Director General  
Agricultural Research Corporation

### **Main Points Discussed on the 5<sup>th</sup> JCC meeting**

The following items were discussed during the 5<sup>th</sup> meeting of JCC on November 1, 2023 and both the Sudanese and Japanese sides agreed to take necessary actions accordingly.

#### **【Progress of the Activities】**

ARC and Tottori University (TU) explained that they have been holding weekly-basis meeting to monitor the progress of the activities. Most project activities have been progressing as planned and some activities such as 1.2, 2.1, 3.1, 4.1, 5.1, 5.4, and 5.5 were already completed, even though there have been many challenges like coup, COVID-19 and current armed conflict within the project period. As the major achievement by the time of JCC, and as a result of public private partnership approach, the total seed produced by the Project and partners increased greatly from 41.7 tons in 2019/20 season to 13,637 tons in 2022/23 season. This quantity of seed represents a 34.5% of the total national certified seeds produced in 2022/23 season. In addition, informal community-based seed production program for farmers in remote rural areas, intensive training to strengthen the capacity of all stakeholders involved in seed production, etc. have been implemented.

#### **【Reasons for Extension of the Project Implementation Period】**

1. The Project period is from November 2019 until November 2024. Unfortunately, this project started at an exceptional time in the history of Sudan and faced many difficulties during its implementation from 2019 up to now. Therefore, an extension for the Project implementation period is requested from ARC and TU. The detailed reasons for the extension are mentioned below;
2. The political instability and the security situation during the time of the people's revolution against the previous regime since April 2019 delayed the dispatch of the JICA coordinator, which had been originally planned in April 2019, and the Project started from November 2019. Moreover, the political situation after the revolution affected the progress in different project activities, especially the construction of the molecular breeding facilities. Due to the administrative

vacuum in the state institutions after the revolution, we could not progress with the bidding process to assign the consultant and the contractor for the construction.

3. From February 2020, the COVID-19 pandemic affected all activities worldwide. Due to the pandemic, instruments procurement, capacity building and other training activities, construction of the molecular breeding facilities, the dispatch of Japanese experts for in-country training, farmers' field schools, field days and events with larger gatherings were mostly canceled or delayed.
4. In October 2021, a political turmoil occurred and the Project implementation was suspended until February 2022 in accordance with the JICA's policy. This situation led to more delay in implementing all the project activities.
5. Since April 15<sup>th</sup>, 2023, a military conflict started between the Sudanese Armed Forces (SAF) and the Rapid Support Forces (RSF). Although the Project intervention areas are relatively less affected and the Project activities are partially ongoing, this conflict in Khartoum, the capital of Sudan, banned travel, stopped the work in the federal governmental institutions, the banks, factories, and all sectors. This resulted in more delay in the construction of the molecular breeding facility, and the instrument procurement, and the travel between different project sites became very difficult and costly.
6. Therefore, ARC and TU request that the Project end time should be extended from November 2024 to March 2025. This extension will allow proceeding with the construction of the molecular breeding facility, implementation of the in-country training, holding a research symposium, and completion of other research and capacity-building activities. In addition, the Project could have one more wheat season, and through Innovation Platform (IP) activities, more farmers could get benefit from technical intervention at IP sites including provision of quality seeds and technical advices to further enhance wheat productivity and farmers livelihoods.
7. JICA understood the necessity of the extension and agreed to take necessary steps for extension.

#### **【Laboratory Rehabilitation and Procurement of the Equipment】**

8. ARC explained that regarding the contract for the lab rehabilitation, Tottori University and the construction company signed the contract in December 2022. The construction company started the work such as removal of the roof

and interior work. Despite military conflict, the company continued the rehabilitation work. Now the company is finalizing 1<sup>st</sup> progress report to ARC and will have inspection by ARC for the next step. The completion of laboratory rehabilitation is expected in September 2024. Currently, it becomes a problem for the company to find out the type of roof materials specified in the contract. When the conflict started, the company has already ordered the roof from a company in Khartoum and it was in their storage. However, since military conflict started in April, there was no communication between them and the roof material hasn't been delivered to Wad Medani. In this situation, ARC and the company discuss how to solve this problem together with a technical consultant and ARC would share the progress to TU and JICA regularly.

9. ARC and TU also explained that some of the equipment have already been procured and delivered to Wad Medani and that the remaining will be procured within the project period. ARC would continue communicating with TU regarding the procurement and the progress will be updated regularly to JICA.
10. Both sides confirmed that in case that the laboratory rehabilitation and the procurement would not be completed within the Project period, ARC is required to complete the rehabilitation and procurement by its own budget since it is difficult for JICA to continue funding the remaining parts after the Project completion.
11. Taking the above into consideration, all sides agreed to monitor the progress of the laboratory rehabilitation and the procurement equipment based on the regular update by ARC to JICA and review the possibility of their completion within the Project period to discuss necessary follow-up in March 2024.

#### **【Technical Transfer】**

JICA express its appreciations to ARC and Tottori University regarding the significant efforts into technical transfers so far, and JICA understands that the trainings on the use of laboratory equipment which have been conducted in Japan are indispensable to achieve the overall goal and the sustainability of the outputs of the Project. JICA also expressed its expectation that the future when those trainees could fully demonstrate their capacity and transfer and develop their knowledge further in Sudan would be realized soon. ARC explained that four trainees have already completed their PhD, three of them

went back to Sudan and started disseminating their knowledge and experience gained in Japan. ARC understands the importance of technical transfer for the goal of this project.

END.

Annex1: Copy of R/D signed 4<sup>th</sup> Feb 2019 except Annex2-7

Annex2: Revised Plan of Operation (PO)

RECORD OF DISCUSSIONS

FOR

PROJECT FOR THE 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

AGREED UPON BETWEEN

AGRICULTURAL RESEARCH CORPORATION

OF

REPUBLIC OF SUDAN

AND

JAPAN INTERNATIONAL COOPERATION AGENCY

Dated February 4 2019

*Handwritten signature* *Handwritten signature*

Based on the minutes of meetings on the Detailed Planning Survey for the Project for the 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 (hereinafter referred to as "the Project") signed on 10 September 2018 between Agricultural Research Corporation of Sudan (hereinafter referred to as "the Counterpart") and the Japan International Cooperation Agency (hereinafter referred to as "JICA"), JICA held a series of discussions with the Counterpart and relevant organizations to develop a detailed plan of the Project.

The purpose of this record of discussions (hereinafter referred to as "the R/D") is to establish a mutual agreement for its implementation by both parties and to agree on the detailed plan of the Project as described in the followings and the Annexes, which will be implemented within the framework of the Note Verbales exchanged on 23 October 2018 between the Government of Japan and the Government of Sudan.

The Counterpart will be responsible for the implementation of the Project in cooperation with JICA, coordinate with other relevant organizations and ensure that the self-reliant operation of the Project is sustained during and after the implementation period in order to contribute toward social and economic development of Sudan.

Both parties also agreed that the Project will be implemented in accordance with the "Basic Principles for Technical Cooperation" published in December 2016 (hereinafter referred to as "the BP") attached as Annex 7, unless other arrangements are agreed in the R/D.

The R/D is delivered at Khartoum as of the day and year first above written. The R/D may be amended by a minutes of meetings between both parties, except the plan of operation to be modified in monitoring sheets. The minutes of meetings will be signed by authorized persons of each side who may be different from the signers of the R/D.

For

JAPAN INTERNATIONAL  
COOPERATION AGENCY



Makoto TAKAHASHI  
Chief Representative  
JICA Sudan Office

For

AGRICULTURAL RESEARCH  
CORPORATION



Dr. Abubakr I. M. HUSSEIN  
Director General

Witness by

For

Federal Ministry of Agriculture and  
Forests



Dr. Nabeel Ahmed Mohamed Saad  
Director General, International  
Cooperation Directorate

For

Federal Ministry of Finance and  
Economic Planning

Mr. Musa Makin Kabashi  
Director General, General Directorate  
for Foreign Finance

- Annex 1: Main Points Discussed
- Annex 2: Project Design Matrix (PDM)
- Annex 3: Plan of Operation (PO)
- Annex 4: Implementation Structure
- Annex 5: List of Proposed Members of Joint Coordinating Committee
- Annex 6: Monitoring Form
- Annex 7: Basic Principles for Technical Cooperation (December 2016)

## MAIN POINTS DISCUSSED

1. The program under which the Project is implemented:  
Both sides noted that the Project is implemented under the Science and Technology Research Partnership for Sustainable Development (hereinafter referred to as "SATREPS") program, promoted by JICA and Japan Science and Technology Agency (JST) in collaboration. SATREPS aims to develop new technologies and their applications for tackling global issues, and also aims at capacity development of researchers and research institutes in both countries.
2. Implementation Structure:  
The project organization chart is given in the Annex 4. The roles and assignments of relevant organizations are as follows:
  - (1) ARC:  
ARC plays a role as an implementing agency. ARC will assign following personnel.
    - (a) Project Director  
Director General of ARC will be responsible for overall administration and implementation of the Project.
    - (b) Project Manager  
Izzat Sidahmed Ali Tahir, Breeder of the Wheat Research Program of ARC will be responsible for implementation, managerial and technical matters of the Project.
    - (c) Research Group Leaders  
Research Group Leaders of ARC will be responsible for the implementation of the designated outputs referred in the PDM.
  - (2) Sudan Meteorological Authority (SMA):  
SMA will work closely with ARC for the output 4 of the Project in the PDM and provide necessary information on meteorology of Sudan.
  - (3) JICA experts:  
The JICA experts will give necessary technical guidance, advice and recommendations to ARC on any matters pertaining to the implementation of the Project.
3. Project duration:  
Five (5) years from the arrival of the first experts
4. Project sites and Beneficiaries:  
The main project site is ARC headquarter in Wad Medani. The Project will also implement the experimental cultivation of wheat at Hudeiba, Dongola and New Halfa. The direct beneficiaries of the Project are researchers of ARC, SMA and farmers.

5. Joint Coordination Committee  
Joint Coordinating Committee (hereinafter referred to as "JCC") will be established in order to facilitate inter-organizational coordination. JCC will be held at least once a year and whenever deems it necessary. JCC will review the progress, revise the overall plan when necessary, approve an annual work plan, conduct evaluation of the Project, and exchange opinions on major issues that arise during the implementation of the Project. A list of proposed members of JCC is shown in the Annex 5.
6. Exemption of tax and any other charges  
ARC will take necessary measures to exempt the JICA experts from taxes and any other charges on the equipment, machinery and other material necessary for the implementation of the Project, and to exempt the JICA experts from income tax and charges of any kind imposed on or in connection with any emoluments or allowances paid to them and/or remitted to them from abroad for their services in connection with the implementation of the Project.
7. Securing local component:  
ARC has a responsibility to secure the necessary local component for the smooth implementation of the Project.
8. Reports:  
ARC and JICA experts will jointly prepare the following documents.
  - Reports with monitoring sheets based on the Project Design Matrix (PDM) and Plan of Operation (PO) on semi-annual basis until the project completion. The format of the monitoring form is attached as Annex 6.
  - Project Completion Report at three (3) month before the completion of the Project.
9. Climate change (adaptation):  
The both sides acknowledge that this project contributes to enhancing adaptation measures to climate change in Sudan and Sub-Saharan Africa, since the project aims at developing climate change resilient wheat germplasm and the appropriate wheat production method.
10. Environmental and Social Considerations:  
With regard to the Section 10.1 of the BP, the Project is likely to have minimal adverse impact on the environment and society under the 'JICA Guidelines for Environmental and Social Considerations (April 2010)'.

END





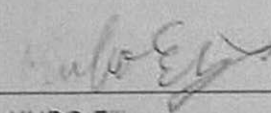


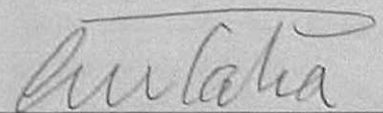
MINUTES OF MEETINGS  
BETWEEN  
AGRICULTURAL RESEARCH CORPORATION OF THE REPUBLIC OF  
SUDAN  
AND  
JAPAN INTERNATIONAL COOPERATION AGENCY  
ON  
THE PROJECT FOR THE DEVELOPMENT OF CLIMATE CHANGE  
RESILIENT INNOVATIVE TECHNOLOGIES FOR SUSTAINABLE WHEAT  
PRODUCTION IN THE DRY AND HEAT PRONE AGRO-ECOLOGIES OF  
SUDAN AND SUB-SAHARAN AFRICA

Agricultural Research Corporation (hereinafter referred to as "ARC") and Japan International Cooperation Agency (hereinafter referred to as "JICA") conducted the 6th Joint Coordination Committee (hereinafter referred to as "JCC") meeting in August 6th, 2024 with all stakeholders of the Project for the 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 (hereinafter referred to as "the Project").

Due to the discussion in the meeting, both parties agreed on the matters (reached the consensus) referred to in the document attached hereto.

September 26, 2024

  
Mr. KUBO Eiji  
Chief Representative  
Sudan office  
Japan International Cooperation Agency

  
Professor. Abdelmoneim Taha Ahmed  
Director General  
Agricultural Research Corporation

### **Main Points Discussed on the 6<sup>th</sup> JCC Meeting**

The following items were discussed during the 6<sup>th</sup> meeting of JCC on August 6<sup>th</sup>, 2024, and both the Sudanese and Japanese sides agreed to take necessary actions accordingly.

#### **[Progress of the Activities]**

From the Japan Science and Technology (JST) side, the project was planned to be implemented from April 2019 to March 2024, but at the 5th JCC meeting, it was agreed to extend the project activities until the end of March 2025. The project major achievements and challenges were presented. The Project consisted of five groups: Breeding, Quality, Physiology, Climate Change and Capacity Building. Besides others, the project objectives included; 1) Human capacity development to ensure sustainability in/after the project, 2) Construction and equipping of the Molecular Breeding Facility in Wad Madani, which was suspended due to the spread of fighting to Gezira State. 3) Dissemination and scaling up of improved wheat production technologies to the farmers through six Innovation Platforms (IPs) established in four states.

Despite the difficult situation in the country, the project was able to implement several activities in most of the IP sites. A booklet of all technological options for wheat production was produced and distributed to farmers. In addition to technical support to farmers at different innovation platform sites, intensive training workshops were conducted to strengthen the capacity of all stakeholders along the wheat value chain (including conducting four training workshops in collaboration with WFP, technical symposia, field and harvest days, etc.).

As a continuation of seed production plans, over 15 tons of seeds were processed, purchased, and distributed to seed producers and farmers. The strong public private partnership approach established for effective and sustainable seed production continued. Due to the security situation, the main seed production sites were Northern, River Nile and Kassala states. The total amount of seed produced in 2023/24 by the project partners using seeds originating from the Project was 10,090 tons. Although the exact total amount of seed produced nationally is not yet known, it is estimated that this amount

represents about 40% of the total certified seed produced nationally

ARC and Tottori University (TU) explained that they have been holding weekly-basis meetings to monitor the progress of the activities. The Project team was monitoring the security situation, especially in Gezira, the research station's hub. In June 2024, the project team proposed an alternative plan with the adjustment of the budget, which was discussed during the 6<sup>th</sup> JCC meeting.

Even though there have been many challenges like the revolution in 2019, COVID-19, Political turmoil in 2021, and current armed conflict that spread into one of the major project areas, the Gezira State, most project activities have been progressing as planned and some activities such as 1.2, 1.3, 1.8 & 1.9, 2.1, 2.2, 3.1, 4.1, 4.2, 5.1, 5.3, 5.4, and 5.5 were already completed.

#### **[Plan of the Activities until March 2025]**

1. Strengthening research facilities that can enable wheat scientists in different research stations to conduct efficient research and develop new cultivars/technology needed for future wheat production.
2. Purchasing certified seeds to establish a distribution cycle that can help in sustaining seed availability for 2-3 seasons.
3. Purchasing seed production equipment necessary for efficient basic and pre-basic seed production by breeders at different research stations.

#### **[Discussion on alternative Plan 2024-2025]**

1. ARC explained that since the invasion of Gezira in December 2023 major activities had been stopped such as rehabilitation of molecular breeding facility, installation of the glass house, procurement and delivery of some equipment. Despite this complicated situation, project activities are still ongoing in the other project intervention sites (New Halfa, River Nile and Northern states) that have 4 innovation platforms. Accordingly, it became necessary to change the project plan and implement other activities that can strengthen and contribute to the sustainability of wheat research and production of certified seeds that ultimately contribute to food security in Sudan.

2. ARC and TU also confirmed that to keep the program active, these research stations should be strengthened with equipment and should conduct the work that used to be conducted in the Gezira Station. Survey was conducted for prioritization of the needed equipment in other research stations with possibility of local procurement. TU would continue communicating with ARC regarding the procurement and the progress will be updated regularly to JICA.
3. Both sides confirmed that the purchased seeds will be used during the project period to be distributed to farmers in October and November and expected to increase the productivity by 20-30% as well as the equipment will be procured in the rest of the project period with timely completion.
4. ARC is requested to be more flexible in allocating the funds to cover the necessary expenses for the project in a timely manner.
5. Taking the above into consideration, both sides agreed to revise the working plan mentioned above. Based on this revised working plan, a new budget plan was also proposed by ARC and TU (detailed plan is mentioned in Annex1) and agreed by both sides.

**[Conclusion]**

JICA express its appreciations to ARC and TU regarding the significant efforts to achieve the overall goal and the sustainability of the outputs of the Project under current difficult security situation in Sudan.

**Annex1:** Changing of working plan and new budget plan

END

### **Changing of working plan and new budget plan**

This project had several objectives and targets that were expected to be met by the end of the project period including

1. Training of six PhD students
2. Production and distribution of different seeds categories
3. Establishment of innovation platforms and training of farmers and other stakeholders within the wheat value chain
4. Establish multimedia resources and project website for information dissemination and training
5. Establishment of molecular breeding facility that includes a molecular breeding facility, glass house and experiment preparation, management and data collection facility.

All the project planned activities were progressing in timely manner except of some delays associated with the pandemic of COVID-19 and the political situation of Sudan. However, since the armed conflict between the Sudan armed force and the Rapid Support Force in April 2023, and the invasion of Gezira state by Rapid Support Force in December 2023 all the activities of molecular breeding establishment stopped. Despite this complicated situation, project activities are still ongoing in the other project intervention sites (New-Halfa, River Nile and Northern states) that have 4 innovation platforms.

Under this difficult situation in Gezira and the uncertainty about when the armed conflict will cease it became necessary to change the project plan and implement other activities that can strengthen and contribute to the sustainability of wheat research and production of certified seeds that ultimately contribute to food security in Sudan. The proposed new plan focusses on:

1. The strengthen of the research facilities that can enable the wheat breeders in different research stations to conduct efficient research and develop new cultivars needed for the future of wheat production in Sudan.
2. Purchasing of new varieties certified seeds to establish a distribution cycle that can help in sustaining seeds availability for 2-3 seasons.



3. Purchasing of seed production equipment necessary for efficient basic and pre-basic seeds production by breeders at different research stations.

The detailed expenditure of the proposed plan is summarized in the table below.

The proposed expenditure plan from August 2024- March 2025

Items	Estimate (JPY)	Notes
Equipment	12,000,000	Different equipment and instruments for plant selection and analysis. It can increase the efficiency of the selection in the breeding program
Seeds purchasing	16,000,000	To establish sustainable certified seed flow for 2-3 seasons
Project Symposium	6,000,000	To hold the final project workshop
Seed production equipment (Harvesters, seed drill, tractors, pivot irrigation system,... etc)	34,000,000	To sustain the production of basic and pre-basic seeds by breeders at the research stations
Additional 6 months program	2,000,000	For Monir and Almutaz
Personnel	2,000,000	Project management at Tottori University
Domestic and international Travel	10,000,000	To disseminate the project results, official and research meetings
Total	82,000,000	

Break down expenses for the project symposium

Item	Estimated budget (JPY)
International Travel cost	3,500,000
Domestic travel cost	100,000
Material preparation (printing proceeding, posters, book)	2,000,000
Unseen cost	400,000
Total	6,000,000

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Aut