

# 1. APPLICATION FOR FUNDING

## ACADEMIC COLLABORATION IN THE BALTIC SEA REGION 2022

SECTION A – MAIN APPLICANT (Swedish university/research institute)	
Name of university	Swedish University of Agricultural Sciences
Project leader, Full name	Mahubjon Rahmatov
Project leader, department/unit/institute	Plant Breeding
Project leader, Title	Researcher
Project leader, E-mail	Makhbubdzhon.Rahmatov@slu.se
Project leader, Telephone	040415342

SECTION B1 – PROJECT DETAILS	
Project name/title	Portfolio of technology transfer for acceleration and improvement of wheat breeding activities in Ukraine
Thematic area	Support for the academia in Ukraine
Project period <sup>1</sup> (YYMMDD – YYMMDD)	221201 - 240531
Number of partners, incl. main applicant	11 in total, SLU (1), Lantmännen (1), LAMMC (4), and PBGI-NCSCI (5)

SECTION B2 – PROJECT DESCRIPTION	
Short summary of the project. Max. 1 000 characters.	
<p>Ukraine's agricultural economy relies heavily on wheat, providing 10% of the global breadbasket as the source of daily protein and calories. The Russian invasion has adversely affected research activities at one of the leading Ukrainian wheat research centre, the Plant Breeding and Genetics Institute - National Center of Seed and Cultivar Investigation (PBGI-NCSCI). In addition to war efforts, biotic and abiotic factors, climate change, and edaphic factors limit the sustainable wheat production system. A SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis was conducted at PBGI-NCSCI based on communication and situation analysis to formulate this proposal; thus, this project aims to strengthen researchers' capacity at PBGI-NCSCI via Swedish-Ukrainian-Lithuanian partnerships. Hence, this will be achieved through (1) demonstrating high-throughput phenotyping systems; (2) introducing a speed breeding system; and (3) strengthening the capacity-building of wheat researchers.</p>	

SECTION B3 – PROJECT GEOGRAPHY (specify included countries)	
Main applicant	Sweden
Country of priority	Ukraine
Additional partner countries <sup>2</sup>	Lithuania

<sup>1</sup> Indicate the anticipated project period (max. 18 months), with a starting date between 1 December 2022 – 31 January 2023.

<sup>2</sup> Possible partner countries are Armenia, Azerbaijan, Estonia, Georgia, Latvia, Lithuania, Poland, Moldova, and Sweden.

SECTION C – CAPACITY/EXPERTISE/EXPERIENCES OF MAIN APPLICANT
Brief summary of capacity, expertise and experiences at the main applicant, of relevance for this project. It may as well include references to other projects/activities, and knowledge of the countries involved in this project. Max. 1 500 characters.
<p>Dr. Mahbubjon Rahmatov (MR) has extensive experience in plant breeding, field-based phenotyping, omics, genomic enabled breeding, sequencing, and capacity building. Also, MR collaborates with non-profit research organizations (e.g., CIMMYT and ICARDA) and UN organizations (FAO, UNDP, and UNEP), including aid and development agencies (USAID and Sida). He has ongoing research projects with the USDA - Agricultural Research Service, the University of Minnesota, ICARDA, CIMMYT, and the John Innes Center to improve wheat crops in Ethiopia, Kenya, and Uganda. Furthermore, he has three VR Development projects for Sudan and South Sudan to improve Pearl Millet, Sesame, and Sorghum in conflict-affected areas. The FAO Regional Office for Europe and Central Asia (FAO-REU), which includes Ukraine as a member, hires MR as an international consultant in plant protection and production based on when actually employment (home-based consultation). MR's consulting efforts at FAO resulted in over \$5 million in funding for numerous Concept Notes and Project Proposals (e.g., \$425k, TCP/SEC/3403, \$600k, GCP/SEC/3707/TUR, \$1,067 million GCP/SEC/016/TUR, etc.). MR attended the International Winter Wheat Traveling Seminar in Ukraine in 2009, which resulted in collaborations and networking with PBGI-NCSCI researchers. Thus, his national and international efforts to combine knowledge in plant breeding, genetics, agronomy, and capacity building reasonably contributed to crop improvement and food security.</p>

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**SECTION D – PROJECT TEAM**

Describe briefly the team of key personnel responsible for management and coordination of the project, at the main applicant and at partner organisations. Max. 1 500 characters.

To leverage existing intellectual and infrastructure strengths, this project will be carried out in collaboration with SLU, Lantmännen, PBGI-NCSCI, and LAMMC. The participants in this project have extensive experience in various academic collaboration projects and capacity building, as well as a high level of scientific research capacity. The research undertaken by the research team of this proposal has made a major contribution to crop research nationally and internationally through the genetic dissection of yield potential, quality, genetic gain, translational genomics, omics, phenomics, biotic and abiotic stress tolerance. LAMMC's research group has a strong background in high-throughput and precision plant phenotyping (WP1). Dr. Rita Armonienė is a senior researcher in genetics with expertise in artificial and field wheat experiments, which focus on the adaptation of wheat to abiotic and biotic stress. Researcher and wheat breeder Andrii Gorash specializes in wheat breeding. Dr. Andrius Aleliūnas specializes in wheat phenotyping and image processing. Junior researcher Gabija Vaitkevičiūtė has experience in performing freezing tests and phenotyping of shoot biomass using consumer-grade cameras in winter wheat. Tina Henriksson provides the in-kind contribution for demonstrating the wheat breeding program and seed production system in Lantmännen. Olga Molodchenkova will serve as project coordinator and be responsible for overall project implementation at PBGI-NCSCI.

SECTION E – RISK ANALYSIS<sup>3</sup>

State identified possible risks relevant to the project (left column), along with appropriate actions (middle column) and responsible function/role/partner (right column). Remember that the explicit mentioning of risks related to corruption and/or misuse of funding is mandatory. **The risk analysis should be comprehensive and will be evaluated by SI.**

Risk	Action	Responsibility
Security situation deteriorates – conflict prevents or discourages researchers from traveling to Lithuania and Sweden	Online training and workshop  Providing protocols and guidelines for the implementation of WPs 1 and 2 activities to the PBGI-NCSCI researchers	Follow the guidance of the Swedish and Lithuanian MFA, the Ukrainian Government, and UN and EU
Limits/prevents researchers' daily activities at the PBGI-NCSCI	National security protocols rigorously followed	Researchers from PBGI-NCSCI will closely monitor the situation following national security protocols
A continuous and active war could damage PBGI-NCSCI's research infrastructure	Scheduled activities and action plan delayed	Researchers from PBGI-NCSCI will closely monitor the situation following national security protocols
Unable to use budgeted fund and complete project on time due to ongoing war in Ukraine	A close monitoring of the situation in Ukraine based on international and national recommendations	Security measures in Ukraine are observed and reported by the main applicant and other participants.
Risk related to corruption – project efficiency dramatically declines, which results in complete failure	We very strictly follow the Penal Code of Sweden (1962:700), Lithuania (No. IX-904), and Ukraine (No. 49, Art. 2056) for the prevention of corruption	Main applicant and others are responsible for ensuring the budget are used as justified per WPs
Misuse of funding	SLU's rigorous policy against corruption audited and monitored all economic transactions	Ernst and Young and SLU have signed a contract for external auditing of research projects

Communication between partners	Scheduled activities and action plan delayed	Communication, discussion, and physical/digital meeting to find the solution if something arise
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

<sup>3</sup> If the risk analysis is provided to the application with a separate enclosure instead, please indicate this in any of the fields above.

SECTION F – PROJECT BUDGET (AMOUNTS IN SWEDISH KRONOR - SEK)	
KO1 Project management (costs at main applicant)	60,000
KO2 Project administration (costs at partners)	33,000
KO3 Implementation	150,000
KO4 Meetings	137,000
KO5 Analysis & Follow-up	94,000
KO6 Communication (external)	30,000
KO7 Mobility (short-term)	26,000
KO8 Mobility (long-term)	430,000
KO9 Overhead <sup>4</sup> (OH)	40,000

<sup>4</sup> Max. 15 % of SI grant applied for.

Other costs <sup>5</sup> (if applicable, specify below)	
In-kind contribution by Mahbubjon Rahmatov, which includes salaries, social fees, premises, and indirect costs)	294,000
In-kind contribution by Tina Henriksson	30,000
In-kind contribution by Rita Armoniene	45,000
<input type="checkbox"/>	

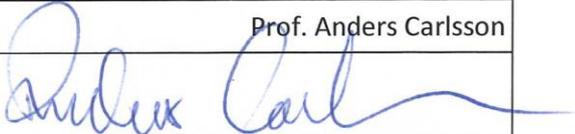
<sup>5</sup> Costs outside KO1-KO9 should primarily use other funding than the SI grant.

Amount applied for, from the Swedish Institute	1000000 SEK
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Other grants/sources of funding <sup>6</sup> (if applicable)	
PCR reagents, KASP buffer, PCR plates, etc. at SLU	60,000
Chemicals and other associated costs for the Ukrainian researcher's visit at SLU	40,000
Consumables for basic lab and field needs at LAMMC	50,000

<sup>6</sup>Including possible co-funding from main applicant or partners.

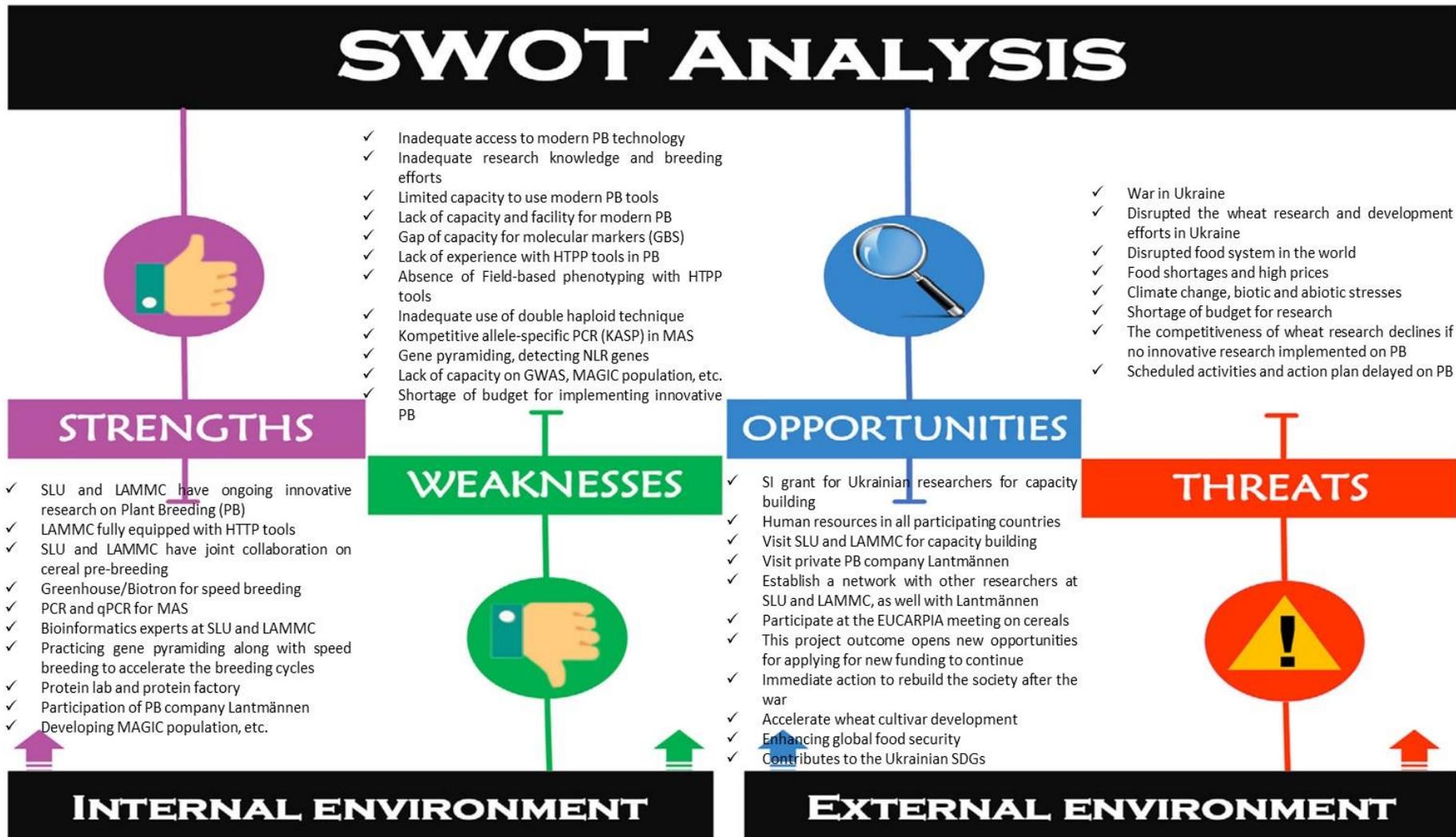
Total project cost	1,519,000 SEK
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SECTION G – AUTHORIZED SIGNATORY AT MAIN APPLICANT (not same as the project leader)	
Place and date	Alnarp 20220928
University/organization	Swedish University of Agricultural Sciences, Department of Plant Breeding
Full name	Prof. Anders Carlsson
Signature <sup>7</sup>	

<sup>7</sup>SI accepts digital signatures.

## Appendix 2: Needs analysis

The idea for this project arose from communication and situation analysis conducted with researchers from Plant Breeding and Genetics Institute - National Center of Seed and Cultivar Investigation (PBGI-NCSCI) to identify and agree upon the challenges and strategic priorities. The SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis identified the main problems related to sustainable plant breeding research and development at PBGI-NCSCI. Thus, the PBGI-NCSCI proposed this project for capacity building for promoting innovative plant breeding techniques. Collaboration and network building can enhance the capacity and development of PBGI-NCSCI researchers. Training courses and workshops will facilitate knowledge transfer and help implement modern research approaches into wheat breeding programs. Researchers from Ukraine are interested in speeding up wheat breeding cycles, developing high-throughput phenotyping techniques, identifying genes associated with resistance to abiotic and biotic stresses (gene pyramiding), and detecting nucleotide-binding and leucine-rich repeat (NLR) gene(s) to biotic stresses.



## Appendix 3: Purpose of the project (Purpose of project)

### Portfolio of technology transfer for acceleration and improvement of wheat breeding activities in Ukraine

#### Purpose and aims

In the long term, this project is expected to have a significant impact on wheat improvement research in Ukraine. The principal objective of this project is to strengthen the capacity development of Ukrainian wheat researchers at Plant Breeding and Genetics Institute - National Center of Seed and Cultivar Investigation (PBGI-NCSCI) through collaboration and networking, but the scope is not limited to research activities. Also, several ongoing research projects involving cutting-edge wheat breeding innovations and high-throughput phenotyping systems will be demonstrated to Ukrainian researchers by the Swedish University of Agricultural Sciences (SLU), Lantmännen, and the Lithuanian Research Centre for Agriculture and Forestry (LAMMC). Thus, the project's outcome should contribute to Ukraine's national development goal for sustainable agricultural research and breeding. Indeed, this project is consistent with the national development goals, fits within Ukraine's vision for agriculture transformation that contributes directly to achieving the National Agriculture Strategy's objectives ([National-Pathway Ukraine.pdf \(summitdialogues.org\)](#)). This will enhance Ukrainian agricultural research potential to improve production efficiency, thereby meeting the growing food needs of the developing world and improving the security of the global food supply. Consequently, this project contributes to the Ukrainian Sustainable Development Goals (SDGs), particularly ones 1, 2, 3, 13, 15, and 17 ([Sustainable Development Goals | United Nations in Ukraine](#)).

#### Rationale and significance of the project in the knowledge chain

Ukraine is one of the top-five grain exporters on the global market, supplying more than 45 million tonnes of grain each year to the global market, particularly to food-insecure countries ([The Russia-Ukraine grain agreement: What is at stake? | IFPRI : International Food Policy Research Institute](#)). Having **exported 20 million tonnes of wheat in 2021**, Ukraine has a **10 percent share of the wheat for global breadbasket** ([Another food crisis? – CIMMYT](#)). Several countries in Africa and the Middle East heavily rely on wheat imports from Ukraine, putting their wheat supplies at risk ([Near- to long-term measures to stabilize global wheat supplies and food security | Nature Food](#)). Because of both the Ukraine-Russian conflict and the COVID-19 pandemic, global food supply chains have been disrupted, leading to shortages and high prices. The Swedish National Statement at the 77th General Assembly of the United Nations also reiterates this point ([Sweden | General Assembly of the United Nations](#)). Additionally, the abiotic and biotic stresses, climate change, and edaphic factors pose significant obstacles to the sustainability of wheat production in Ukraine, endangering food and nutrition security. Thus, plant breeding is the basis for a sustainable solution to address the aforementioned challenges to improve food and nutritional security throughout the whole food value chain.

Unfortunately, the majority of Ukrainian scientists have left the country ([Ukraine's scientists need help to rebuild their research system \(nature.com\)](#)), and those who remain are in need of assistance in rebuilding their research activities. There is also a shortage of researchers and decreased availability of scientific resources because of widespread displacement and the rapid mobilization of Ukrainian society for the war effort. We conducted SWOT (Strengths, Weaknesses, Opportunities, and Threats) analyses through communication and situation analysis to determine what assistance is required for performing research activities in PBGI-NCSCI. Based on the SWOT analyses, it was revealed that researchers at PBGI-NCSCI urgently need capacity building for wheat research and development efforts. Through this proposed project, the main objective is to assist Ukrainian wheat researchers at PBGI-NCSCI in rebuilding their research system through Swedish-Ukrainian-Lithuanian collaborations. Providing capacity building for wheat researchers is the cornerstone of this project, which contributes to accelerating the Ukrainian wheat-breeding program toward national and global food and nutritional security.

#### Project procedure

##### **Work Package 1: High-throughput and precision plant phenotyping**

High-throughput plant phenotyping (HTPP) using unmanned aerial vehicles (UAVs), robots, and phenocarts is becoming increasingly popular in plant breeding research for rapid phenotyping of many field-grown plants. Using HTPP, breeders can predict grain yield, biotic, and abiotic stresses, including agronomic attributes. The use of HTPP platforms can therefore increase

breeding cycle accuracy and speed while reducing manual labor and associated costs. The implementation of HTPP usually requires training for the setting of phenotyping platforms and data analytics, and as of yet, HTPP has not been integrated into Ukrainian cereal breeding programs. LAMMC leads an international project 'NOBALwheat – breeding toolbox for sustainability in the NOrdic BAltic region, which has gained field phenotyping experience by using UAVs, phonecars, and image analysis. As part of this WP, the partners will gain know-how and technology transfer and introduce novel plant phenotyping techniques to wheat breeding programs in Ukraine, ensuring sustainable food systems. Wheat breeding research conducted at LAMMC routinely utilizes HTPP to estimate shoot biomass growth and canopy temperature dynamics in response to biotic and abiotic stressors, including freezing tolerance tests. Thus, acquiring these methodologies will benefit partners since they do not require expensive sensors and can be adapted to various laboratory environments. A double haploid (DH) technique is routinely used in wheat breeding in LAMMC, so breeding cycles are significantly reduced when combined with speed breeding and association analysis (WP2).

### **Work Package 2: Accelerating the wheat breeding process for multiple traits**

Currently, the Ukrainian wheat-breeding program requires long breeding trajectories to develop demanded wheat cultivars. However, speed breeding method has revolutionized crop cultivars development by accelerating plant breeding cycles ([Speed breeding is a powerful tool to accelerate crop research and breeding | Nature Plants](#)). Wheat cultivars developed by Ukrainian wheat breeding programs contribute to ~10% of global food security, providing global citizens with a source of daily protein and calories ([Near- to long-term measures to stabilize global wheat supplies and food security | Nature Food](#)). By incorporating speed breeding into current Ukrainian wheat breeding program, cultivar development is accelerated to maintain and strengthen the wheat's competitiveness in international markets. Speed breeding and high-throughput phenotyping are employed at SLU and LAMMC research activities for crossbreeding, development of mapping populations, and adult plant phenotyping for specific traits, including Lantmännen's wheat breeding program. By integrating high-throughput genotyping (marker-assisted selection) and phenotyping technologies (WP1), this WP aims to demonstrate accelerating wheat breeding cycles to Ukrainian researchers (Figure 1 and Table 1). Currently, we use genotyping-by-sequencing (GBS) technology in our research projects in combination with speed breeding to maximize genetic gains. Moreover, the GBS dataset enables us to identify NLR genes and develop kompetitive allele-specific PCR (KASP) maker ([Identification of a small translocation from 6R possessing stripe rust resistance to wheat | Plant Disease \(apsnet.org\)](#)). We will also demonstrate to Ukrainian researchers gene pyramiding, genome-wide association studies (GWAS), genomic selection, end-use quality parameters, and advanced generation intercross populations (MAGIC) approaches. Thus, this WP provides sufficient evidence from the academic (SLU) and private company (Lantmännen) perspective to support the development of a speed breeding program for Ukrainian wheat breeding programs.

### **Work Package 3: Strengthening knowledge and capacities development: Ensuring for accelerating wheat breeding process at PBGI-NCSCI**

The overall project activities start with demonstrating high-throughput phenotyping (WP1) and accelerating the wheat breeding process (WP2) for the Ukrainian wheat researchers at PBGI-NCSCI. Sustainable Development Goal 4 aims at ensuring inclusive and equitable quality education and promote lifelong learning opportunities for all. The wheat researchers from PBGI-NCSCI will be trained at SLU, Lantmännen and LAMMC throughout WP1 for high-throughput phenotyping and WP2 for accelerating the wheat breeding process. In addition, the researchers from the PBGI-NCSCI will attend [Eucarpia - EUCARPIA Cereals Section Conference](#) to present their research projects and build their professional network. The WP will follow the SI funding program for the Baltic Sea region's macro-regional strategy ([EUSBSR - Interreg Baltic Sea Region \(interreg-baltic.eu\)](#)) to strengthen Ukrainian researchers' capacity to ensure long-term productivity, sustainability, and competitiveness in wheat research.

### **Expected project outcome**

Ultimately, the project will strengthen the capacity development of Ukrainian wheat researchers at PBGI-NCSCI. This will also improve the wheat scientists' research potential at PBGI-NCSCI to accelerate wheat cultivar development. Further, this will serve as a foundation for a potential donor application to improve wheat breeding research and facilities in Ukraine.

## Appendix 4: Target groups

This project will be carried out in collaboration with the Swedish University of Agricultural Sciences (SLU), Department of Plant Breeding (Alnarp, Sweden), Lantmännen Lantbruk (Svalöv, Sweden), Lithuanian Research Centre for Agriculture and Forestry (LAMMC), and Plant Breeding and Genetics Institute - National Centre of Seed and Cultivar Investigation (PBGI-NCSCI). The participants from all institutions have extensive experience in various development-oriented research projects and possess high scientific expertise. Researchers associated with this proposal have made significant contributions to crop research in genetics, yield potential, cereal breeding, quality attributes, genetic gain, sequencing, translational genomics, omics, phenomics, and stress tolerance under biotic and abiotic conditions. Dr. Mahbubjon Rahmatov from SLU, and Dr. Rita Armonienė from LAMMC have comprehensive experience in plant breeding, field-based phenotyping, high-throughput plant phenotyping, GWAS, plant genetic resources conservation, omics, handling of big data, genomic enabled breeding, sequencing, capacity development, and various laboratory analyses. Tina Henriksson from Lantmännen has broad experience in cereal breeding and seed production systems from a private company perspective and her participation greatly enhances the project. Moreover, four Ph.D. students (Mohammed Elsafy, Olawale Olalekan, Mahboobeh Yazdani, and Ashraf Rimsha) will participate in the implementation of WP2 at SLU for Ukrainian researchers. With his extensive experience in wheat breeding, field-based selection, and maintenance breeding, Andrii Gorash leads the LAMMC wheat-breeding program, whose participation contributes substantially to the project's implementation. Furthermore, the participation of Dr. Andrius Aleliūnas and PhD student Gabija Vaitkevičiūtė will strengthen the demonstration of phenocart in the field, freezing tolerance, image processing and analysis and the double haploid method for Ukrainian researchers at LAMMC.

This project is formulated with the cooperation of researchers at the PBGI-NCSCI. The PBGI-NCSCI is one of the leading research centre in crop science in Ukraine (<http://www.sgi.in.ua/>). Dr. Olga Molodchenkova serves as the project coordinator at the PBGI-NCSCI. Dr. Olga Molodchenkova is a leading researcher at PBGI-NCSCI, specializing in physiological and biochemical mechanisms regulating wheat plant defense reactions under biotic and abiotic stress, including developing biochemical methods for controlling wheat resistance to biotic and abiotic stress factors to be used for wheat breeding for selecting high-quality, productive, stable varieties. We digitally communicated with the researchers at the Department of Wheat Breeding and Seed Production (Professor Lytvynenko Mykola), Department of Phytopathology and Entomology (Dr. Vasiliev Alexey and Dr. Olga Babayants), Department of General and Molecular Genetics (Dr. Fait Viktor and Dr. Motsnyi Ivan), and Department of Resistance to Abiotic Factors (Dr. Pavel Feoktistov), and Laboratory of plant tissue culture (Dr. Zambriborshch Irina) at the PBGI-NCSCI, and Professor L. Mishchenko from the Taras Shevchenko National University of Kyiv. As a result of our communication and SWOT analysis, we formulated this proposal for capacity building for Ukrainian researchers at SLU and LAMMC. This proposal brings together internationally renowned experts in cereal breeding research with a unique range of skills covering breeding, genetics, omics, high-throughput plant phenotyping, phenomics, and capacity building, including an expert on extension services. As a result, capacity will be built not only for research on cereals but also on other important crops in Ukraine and beyond. All participating researchers are well qualified to lead this project successfully to achieve an outstanding outcome for strengthening Ukraine's agricultural research and development systems.

## **Appendix 5: Layout (Work plan)**

### **Comprehensive overview of the project layout**

Wheat is the most important staple food and commodity crop in Ukraine. Aside from being an economically viable crop, Ukrainian wheat also plays a fundamental role in providing food for the developing world and enhancing global food security. Unfortunately, the Russian invasion has disrupted the country's wheat research and development efforts. On top of this, wheat production is impacted by biotic and abiotic stresses, climate change, and edaphic factors nationwide. Plant Breeding and Genetics Institute - National Center for Seed and Cultivar Investigation (PBGI-NCSCI), one of the leading Ukrainian wheat research centre, has been hampered in its research activities and the developing of high-yielding, high-quality, and superior-adapted wheat cultivars due to the above challenges. As a result, researchers' activities are hindered, resulting in inadequate research knowledge and breeding efforts. Agricultural research and breeding programs play an important role in ensuring resilient agri-food systems, food security, and environmental sustainability. A SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis was conducted to identify key issues facing implementing agricultural research and breeding activities using communication and situation analysis with researchers from the PBGI-NCSCI. Based on SWOT analyses, the project aims to strengthen the capacity of researchers at PBGI-NCSCI to maintain research knowledge through joint collaboration and networking. Thus, this project will enhance Ukrainian wheat researchers' capacity development through Swedish-Ukrainian-Lithuanian partnerships that contribute to national and global food and nutritional security. This will be accomplished by (1) Demonstration of field-based high-throughput phenotyping systems for wheat breeding; (2) Introduction of speed breeding in wheat improvement; and (3) Strengthening capacity-building through training and workshops in Sweden and Lithuania (Figure 1 and Table 1). The outcome of this project is to improve Ukrainian researchers' knowledge of current research and development efforts in wheat improvement, which may contribute to the restoration of society after a war. This project will also provide a foundation for preparing funding applications to other potential donors to enhance the wheat-breeding program in Ukraine.

### **Most important outcomes for the country**

The proposed project contributes directly to the focus of the call and is in line with sub-target two of the Swedish government's policy for global development ([Biståndspolitisk plattform - Regeringen.se](https://www.regeringen.se/pressmeddelanden/2018/08/20180814111111)), which aims to create better living conditions for people living in poverty and conflict zones. The Foreign Minister of Sweden, Ann Christin Linde, also addressed this issue during the General Debate of the 77th session of the United Nations General Assembly ([Sweden | General Assembly of the United Nations](https://www.sve.se/nyheter/2022/09/20220926111111)). This project will strengthen high-quality academic cooperation between Sweden, Ukraine, and Lithuania. Moreover, the project will provide an excellent opportunity for adapting and utilizing the research knowledge obtained at SLU (Sweden) and LAMMC (Lithuania) for wheat improvement in Ukraine. PBGI-NCSCI will strengthen its wheat breeding capacity by adopting technologies and innovative practices through the Swedish-Ukrainian-Lithuanian strategic partnership. With the acquired knowledge, PBGI-NCSCI will develop a high-throughput, precision plant phenotyping (WP1) as well as a wheat breeding procedure (WP2), which may contribute to the acceleration of wheat breeding processes. These techniques are becoming faster and more capable, and their cost is minimum. This is an important opportunity for Ukrainian researchers to collaborate on developing these techniques. Using these techniques will be a realistic and viable option for developing wheat cultivars within a short period of time.

### **Gender equality and diversity**

The project aligns well with the UN Sustainable Development Goal (SDG) #5 Gender Equality, which includes mainstreaming gender equality throughout the project's implementation. Thus, the project will promote gender equality by involving female and male scientists and integrating the gender dimension into research content. Therefore, gender equality and diversity are well balanced in this project.

### Security situation in Ukraine

The recent military offensive by the Russian Federation has exacerbated the humanitarian situation in Ukraine. Accordingly, we will follow the instructions of the Swedish and Lithuanian Ministry of Foreign Affairs, as well as the Ukrainian Government and UN Security Council, with regard to the security situation for Ukrainian researchers visiting Sweden and Lithuania. Researchers at the PBGI-NCSCI in Odessa are working on the daily routine. We work closely with Ukrainian researchers at the PBGI-NCSCI, and we hope the outcome of this project will strengthen their capacity for innovative plant breeding.

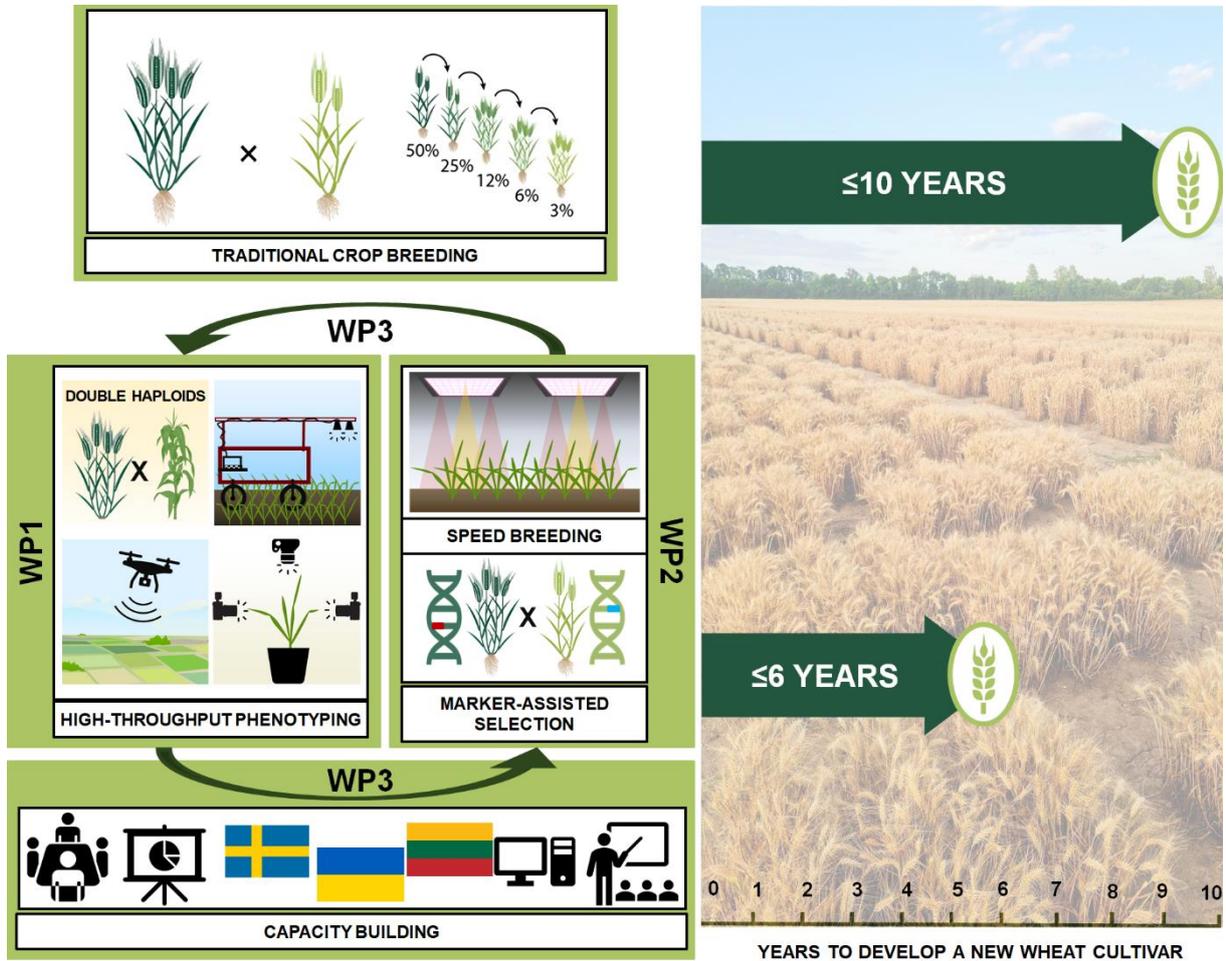


Figure 1. Graphical abstract of the project

**Table 1. Time Plan and Implementation with roles and responsibilities**

Activities	2022	2023											2024					Place	Responsible Person	
	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A			M
<b>Work Package 1. High-throughput phenotyping (Field-based phenotyping)</b>																				
The introduction of wheat breeding activities and techniques at LAMMC																			LAMMC	RA and AG
To demonstrate unmanned aerial vehicle (UAV) phenotyping platforms for wheat breeding programs at LAMMC																			LAMMC	AG and AA
To introduce with processing of image analysis using Pix4DMapper and QGIS																			LAMMC	RA and AA
Plant phenotyping at ground level by phenocart: from field phenotyping to vegetation indexes																			LAMMC	RA and AA
Affordable plant shoot phenotyping for determination of plant biomass and its dynamics																			LAMMC	RA and GV
To demonstrate wheat freezing tolerance evaluation methods applying at LAMMC																			LAMMC	AA and GV
To introduce with wheat double haploid method using at LAMMC																			LAMMC	RA
<b>Wor Package 2. Accelerating the wheat breeding process for multiple traits</b>																				
Demonstrate the speed breeding method in wheat at SLU																			SLU	MY, ME and MR
Demonstrate mapping populations, crossing, and phenotyping of adult plants																			SLU	AR and MY
Visiting Lantmännen wheat breeding program and seed production systems																			Lantmännen	TH
Allelopathic potential analysis in cereal crops																			SLU	MY
Genotyping-by-sequencing (GBS) and bioinformatic analysis for GBS																			SLU	MY, ME, OO and MR
Validating kompetitive allele-specific PCR for specific detected NLR gene from GBS-SNPs																			SLU	AR, MY and ME
The use of KASP markers and speed breeding for multiparent advanced generation intercross (MAGIC) populations																			SLU	AR, MY and ME
Introduction to genome-wide association studies																			SLU	ME, MY and MR
Demonstration of other ongoing research projects at SLU																			SLU	All
Introduction of other labs: Plant product quality, horticulture, biotechnology, tissue culture, etc.																			SLU	MR, and others
<b>Work Package 3. Strengthening knowledge and capacities development: Ensuring for accelerating wheat breeding process at PBGI-NCSCI</b>																				
Researchers visits from PBGI-NCSCI to LAMMC for WP1 activities																			LAMMC	RA
Researchers visits from PBGI-NCSCI to SLU for WP2 activities																			SLU	MR
Participate at EUCARPIA Cereals Section Conference (3/4 participants)																			Hungary	MR and RA
Participate in any relevant courses at SLU and LAMMC related to the project objectives																			SLU and LAMMC	MR and RA
<b>Project management strategy and information-sharing mechanism</b>																				
Regular email communication with participants to update project activities and implementations																			Email	MR, and All
Virtual inception meeting with all project participants																			Zoom	All
Disseminate the project objectives, aims, and progress through social media and online platforms																			All	All
Search and identify any other relevant funding bodies for wheat-breeding research in Ukraine																			All	All
Final workshop																			TBD	All
Final report for project activities, implementation, and financing (Submitted December 2024)																			All	MR, and All

RA - Rita Armonienė; MR - Mahbubjon Rahmatov; TH - Tina Henriksson; AG - Andrii Gorash; AA - Andrius Aleliūnas; GV - Gabija Vaitkevičiūtė; MY - Mahboobeh Yazdani; ME - Mohammed Elsafy; AR - Ashraf Rimsha; OO - Olawale Olalekan

## Appendix 6: Budget

The total budget of the hereby applied project is 1,519,000 SEK, of which 1,000,000 SEK is requested from the Swedish Institute. All the costs applied for this project calculated according to budget rules at SLU, LAMMC, and PBGI-NCSCI. In my group, there are four Ph.D. students (Mohammed Elsafy, Olawale Olalekan, Mahboobeh Yazdani, and Ashraf Rimsha), whose research is described in WP2 for accelerating the wheat breeding process for multiple traits. To demonstrate their ongoing research activities to Ukrainian researchers, all four Ph.D. students will participate in WP2 as part of their ongoing project activities. A research assistant will also assist with this project. Contributions from Ph.D. students and research assistant are not budgeted for this project, to which they also contribute in-kind.

## Budget specification

Budget area	SEK		Organization	Number of person	Duration, month	Budget justification
	2023	2024				
<b>KO1 Project Management</b>						
Project management (Mahbubjon Rahmatov)	0	0	SLU	1	2,7	Mahbubjon Rahmatov will spend 15% of his time for project management, as an in-kind contribution
Project administration	10,000	5,000	SLU			This is allocated for administration purposes at SLU
Bench fee	20,000	0	SLU	4	2	Four Ukrainian researchers will be at SLU, and this budget is for bench fees
External audit	0	25,000	SLU			The budget is allocated for external audit
<b>KO2 Project Administration (costs at partners)</b>						
Project administration at LAMMC	22,000	11,000	LAMMC	33,000		The allocated budget will be used at LAMMC for project administration
<b>KO3 Implementation (Planning)</b>						
Salary for Rita Armoniene (RA)	25,000	20,000	LAMMC	1	1,2	RA allocated 13% of her time, of which 6,7% applied from SI for project management and implementation
Salary for Andrii Gorash (AG)	15,000	10,000	LAMMC	1	0,8	AG allocated 4.5% of his time to the training of Ukrainian researchers at LAMMC
Salary for Andrius Aleliūnas (AA)	15,000	10,000	LAMMC	1	0,8	AA allocated 4.5% of his time to the training of Ukrainian researchers at LAMMC
Salary for Gabija Vaitkevičiūtė (GV)	15,000	10,000	LAMMC	1	0,8	GV allocated 4.5% of her time to the training of Ukrainian researchers at LAMMC
Salary for Olga Molodchenkova (OM)	20,000	10,000	PBGI-NCSCI	1	4	OM allocated 22% of her time for project management and implementation at PBGI-NCSCI
Salary for Tina Henriksson	0	0	Lantmännen	1	0,25	Tina Henriksson will spend 1,5% of her time for demonstrating wheat breeding programs at Lantmännen
<b>KO4 Meetings</b>						
Participating in conference/workshop	67,000	0	SLU	4	0,25	The participation of four Ukrainian researchers in the EUCARPIA Cereals Section Conference
Workshop in Ukraine	0	30,000	PBGI-NCSCI			The workshop will be held at PBGI-NCSCI by researchers who visited SLU and LAMMC about
Final workshop	0	40,000	SLU/LAMMC		0,15	A workshop will be held to finalize the project and finalize the proposal for other potential donors

## Continuous of budget specification

Budget area	SEK		Organization	Number of person	Duration, month	Budget justification
	2023	2024				
<b>KO5 Analysis and follow-up</b>						
Cost of running climate and freezing chamber	0	50,000	LAMMC			The budget is allocated to the LAMMC for the use of the lab facilities during trainings
Lab consumables, greenhouse, etc.	15,000	9,000	LAMMC			The budget is allocated for lab consumables
Lab, greenhouse/Biotron	20,000	0	SLU			This budget is allocated for the lab, greenhouse, and biotron
<b>KO6 Communication (external)</b>						
Publish in open access journals	0	30,000	SLU	30000		The budget is allocated to Ukrainian researchers for publishing their research in open-access journals based on their available research data
<b>KO7 Mobility (short-term, max. 10 workdays per visit)</b>						
Lithuanian researcher traveling/accommodation at SLU	11,000	0	LAMMC	1	0,25	Travel and accomodation cost at SLU
Swedish researcher traveling/accommodation at LAMMC	8,000	7,000	SLU	1	0,25+0,25	Travel and accomodation cost at LAMMC
<b>KO8 Mobility (long-term, max. 6 months/person)</b>						
Accommodation at SLU for Ukrainian researchers	50,000	0	SLU	4	2 + 2	Accommodations at SLU for two researchers in April and May 2023, as well as another two researchers in November and December 2024
Accommodation at LAMMC for Ukrainian researchers	25,000	25,000	LAMMC	4	2 + 2	Accommodations at LAMMC for two researchers in June and July 2023, as well as another two researchers in January and February 2024
Travel (flight, or ground transportation)	25,000	25,000	SLU/LAMMC	4		The budget is allocated for traveling from Ukraine to Sweden and Lithuania
Scholarship in Sweden	160,000	0	SLU	4	2 + 2	The budget is allocated in Sweden, such as food, accommodation, living expenses, etc.
Scholarship in Lithuania	60,000	60,000	SLU	4	2 + 2	The budget is allocated in Lithuania, such as food, accommodation, living expenses, etc.
<b>KO9 Overhead (OH)</b>						
Indirect costs 15% at LAMMC	28,000	12,000	LAMMC			Indirect cost for LAMMC
Overhead	0	0	SLU			OH costs will not be charged since salaries are not allocated to SLU participants
<b>TOTAL</b>	<b>611,000</b>	<b>389,000</b>				

## 7. PARTNER ENCLOSURE

### ACADEMIC COLLABORATION IN THE BSR 2022

SECTION A – DETAILS OF PROJECT PARTNER	
Name of university/organisation	Lithuanian Research Centre for Agriculture and Forestry (LAMMC)
Contact person, Name	dr. Rita Armonienė
Contact person, Title	Senior researcher
Contact person, Department/unit/section/office	Laboratory of genetics and physiology
Contact person, E-mail	rita.armoniene@lammc.lt
Contact person, Country of current location	Lithuania

SECTION B – DETAILS OF SI PROJECT AND AFFILIATION	
Name of project (same as in application to SI)	Portfolio of technology transfer for acceleration and improvement of wheat breeding activities in Ukraine
Partner status	Partner

SECTION C – ROLE AND CONTRIBUTION	
Describe your organisation's role in and expected contribution to the project, related to the needs analysis in the application (enclosure 2).	
<p>LAMMC will contribute by sharing of novel technologies and methods employed in wheat breeding programs at LAMMC. Researchers from LAMMC will lead WP1 dedicated to the transfer of High-throughput and precision plant phenotyping techniques to Ukrainian researchers. Trainings and hands-on courses will be organized during scientific visits of researchers and plant breeders from PBGI-NCSCI (Ukraine) at LAMMC. LAMMC will contribute to establishing and maintaining an academic network between Swedish, Lithuanian and Ukrainian researchers and breeders of wheat for cooperation and capacity building preparing the academia to take an active role in processes to rebuild the society and economics after the war.</p>	

**SECTION D – RELEVANCE FOR TARGET GROUPS OF THE PROJECT**

Describe how your organisation is related to, and relevant for support to the target groups of the project.

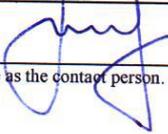
The Lithuanian Research Centre for Agriculture and Forestry (LAMMC) is state research institution in Lithuania. The Centre's strategic objective is to conduct R&D in the fields of agronomy and forestry and the related fields of ecology and environmental sciences, biology, biophysics, botany and zoology. LAMMC conducts breeding programmes for major field and garden crops, pome, stone and berry fruit crops. A team of researchers from LAMMC have experience in plant phenotyping using high throughput and precision phenotyping techniques and processing of image data. The accumulated experience and knowledge will be transferred to Ukrainian scientists during visits and organized training, which will allow new methods to be applied in wheat research and accelerate wheat breeding programs.

**SECTION E – ADDED VALUE FOR YOUR ORGANISATION**

Describe the added value that your organisation is expected to gain by participating in this project.

LAMMC will benefit from know-how and technology transfer among partner institutions. The project will allow the formation and maintenance of research networks and cooperation between the Sweden-Ukraine-Lithuania partnership for capacity development, as well as update research and development knowledge on wheat research which can accelerate wheat breeding programs at LAMMC. Further, this will serve as a foundation to attract funds for future research projects among the project partners.

**SECTION F – AUTHORIZED SIGNATORY (cannot be the same as appointed contact person<sup>1</sup>)**

Place and date	26.09.2022
University/organisation	Lithuanian Research Centre for Agriculture and Forestry
Full name	Gintaras Brazauskas
Position/title	Director
Signature <sup>2</sup>	

<sup>1</sup> Only if the partner status is indicated as *non-partner participant*, the signatory could be the same as the contact person.

<sup>2</sup> SI accepts digital signatures.

## 7. PARTNER ENCLOSURE

### ACADEMIC COLLABORATION IN THE BSR 2022

SECTION A – DETAILS OF PROJECT PARTNER	
Name of university/organisation	Plant Breeding and Genetics Institute - National Center of Seed and Cultivar Investigation
Contact person, Name	Olga Molodchenkova
Contact person, Title	Doctor of Biological Sciences, Head of Laboratory
Contact person, Department/unit/section/office	Laboratory of Plant Biochemistry
Contact person, E-mail	olgamolod@ukr.net
Contact person, Country of current location	Ukraine, Odessa

SECTION B – DETAILS OF SI PROJECT AND AFFILIATION	
Name of project (same as in application to SI)	Portfolio of technology transfer for acceleration and improvement of wheat breeding activities in Ukraine
Partner status	Partner

SECTION C – ROLE AND CONTRIBUTION	
Describe your organisation's role in and expected contribution to the project, related to the needs analysis in the application (enclosure 2).	
<p>Plant Breeding and Genetics Institute - National Centre of Seed and Cultivar Investigation (PBGI-NCSCI) is one of the leading research institutions in agricultural science. The main direction of the PBGI-NCSCI is to develop theoretical, methodological, and practical approaches to improve plant breeding and seed production, including breeding varieties and hybrids of winter bread and durum wheat and maintenance breeding for producing pre-basic seeds and breeders seeds. Currently, a total of 63 winter wheat cultivars developed in PBGI-NCSCI are registered and recommended for cultivation in Ukraine. There is a strong collaboration between breeders and geneticists, phytopathologists, and experts in biochemistry, plant tissue culture, and other theoretical departments within the institution responsible for achieving successful practical results. However, neither genome-wide association studies nor high-throughput phenotyping approaches have been employed in cereal breeding at PBGI-NCSCI. This proposed project will contribute to the capacity building of Ukrainian wheat researchers at PBGI-NCSCI for their research system through Swedish-Ukrainian-Lithuanian collaborations. Therefore, the project helps build capacities for wheat researchers in order to accelerate wheat breeding programs toward food and nutritional security. Ultimately, this project will improve Ukrainian researchers' knowledge of current innovative research and development efforts in wheat improvement, contributing to rebuilding society after the war.</p>	

**SECTION D – RELEVANCE FOR TARGET GROUPS OF THE PROJECT**

Describe how your organisation is related to, and relevant for support to the target groups of the project.

The research and expertise of the Ukrainian group are highly related to those of the Lithuanian and Swedish research groups. Thus, collaboration and knowledge transfer are desirable and will be implemented in wheat breeding programs. This project also provides an opportunity for technology transfer, knowledge sharing, outreach, and awareness campaign via Swedish-Ukrainian-Lithuanian partnerships. Ultimately, the project outcome builds toward a vision to achieve sustainable farm-to-fork systems for global food and nutrition security.

**SECTION E – ADDED VALUE FOR YOUR ORGANISATION**

Describe the added value that your organisation is expected to gain by participating in this project.

Establishing a collaboration between Ukrainian, Swedish, and Lithuanian research groups that have areas of expertise that are highly related and complement each other. Acquiring knowledge about high throughput phenotyping, speed breeding, and the development of molecular markers for traits associated with biotic and abiotic stresses, including joint publication in international journals. Furthermore, this project contributes to the national development goal for sustainable agricultural research and breeding, directly contributing to the objectives of the National Agriculture Strategy. This project provides a foundation for applications to other potential donors to enhance Ukraine's wheat breeding program. Another major benefit of this project is that it provides the basis for proposal submission to other potential donors for enhancing Ukraine's wheat breeding program.

**SECTION F – AUTHORIZED SIGNATORY (cannot be the same as appointed contact person<sup>1</sup>)**

Place and date	30 September 2022
University/organisation	Plant Breeding and Genetics Institute - National Centre of Seed and Cultivar Investigation
Full name	Vyacheslav M. Sokolov
Position/title	Director of Plant Breeding and Genetics Institute-National Center of Seed and Cultivar Investigation
Signature <sup>2</sup>	

<sup>1</sup> Only if the partner status is indicated as *non-partner participant*, the signatory could be the same as the contact person.

<sup>2</sup> SI accepts digital signatures.

