AgriScience Program - Projects Component

Annual Performance Report

Name of Recipient: Canadian Field Crop Research Alliance	
Project Title: Breeding, genomics and agronomy research to improve oat yield and quality	
Project Number: ASP-001	**Period Covered by the Report** (YYYY/MM/DD to YYYY/MM/DD): 2018/04/01 to 2019/03/31
Project Start Date (YYYY/MM/DD): 2018/04/01	**Project End Date** (YYYY/MM/DD): 2023/03/31

1. Performance Measures – Project Level

In the performance measures table below, please provide the results and achievements that were finalized during the reporting period, that combines all the CA and CRDA activities. Do not include results that are not final or that will continue to be developed. It is quite possible that in the first year or two, there may not be any results to report. Please see Annex A for a description of each performance measure.

Performance Measure		Results Achieved	Provide a brief description of each final result achieved during the reporting period.
1.	Number of highly qualified personnel (HQP) working on funded activities		
2.	Training/knowledge transfer events		
	2.1 Number of training/knowledge transfer events organized		
	2.2 Number of presentations made in training/knowledge transfer events	15	1. Weikai Yan: “Oat variety update”. Ottawa Oat Day, July 21, 2018 2. Nick Tinker and Wubishet Bekele: “Genomics-assisted breeding update: Oat genomics: past, present, and future” , Ottawa Oat Day, July 21, 2018 3. Judith Frégeau-Reid: “A new method for genotype and management evaluation based on multiple traits”. Ottawa Oat Day, July 21, 2018 4. Baoluo Ma: “Oat Agronomic Study update: optimum planting densities and planting dates” . Ottawa Oat Day, July 21, 2018 5. Allen Xue: “Surveillance of oat diseases in Ontario, 2008-2017”,

Performance Measure		Results Achieved	Provide a brief description of each final result achieved during the reporting period.
			Ottawa Oat Day, July 21, 2018 6. Charlene Wight: "Your source for oat information…the Oat Newsletter plus" . Ottawa Oat Day, July 21, 2018 7. Terry Phillippe: "Oat production in northern Ontario and wish list for an ideal milling oat cultivar" . Ottawa Oat Day, July 21, 2018 8. Weikai Yan. "2018 Oat variety update". Atlantic Grains Council and Maritime Seed Growers AGM, Moncton NB, December 4, 2018 9. Weikai Yan. "Genotype and management evaluation based on yield-trait combination". Guelph ON, Jan 21, 2019. 10. Weikai Yan. 'Grouping test locations based on existing crop variety trial data", Guelph ON, Jan 21, 2019. 11. Weikai Yan. "Genomics selection: a breeder's perspective", Seattle, WA, June 19-21, 2018 12. Xue, A.G., Chen, Y., Blackwell, B., Harris, L.J., and Overy, D. Aggressiveness of Fusarium poae isolates causing head blight in oat. Proc. 9th Canadian Workshop on Fusarium Head Blight and 4th Canadian Wheat Symposium, Nov. 19 - 22, 2018, Winnipeg, MB, p 62. 13. Nick Tinker et al., Data and Knowledge Management for the Oat Community. AOWC, Seattle, WA, June 19-21, 2018 14. Wubishet Bekele, Asuka Itaya, Charlene Wight, Judith Frégeau-Reid, Weikai Yan, Nicholas Tinker. Genomics-assisted breeding of oat. AOWC, Seattle, WA, June 19-21, 2018 15. Nick Tinker. What the Dickens has Oat Genomics Done for You Lately? The Groats of Christmas Past, Present and Yet-to-Come. POGA'S 21st annual AGM and conference, 2018.

Performance Measure		Results Achieved	Provide a brief description of each final result achieved during the reporting period.
			Sheraton Cavalier, Saskatoon, SK.
3.	Number of participants at training/knowledge transfer events	135	1. Ottawa oat day: 60 2. Atlantic grain council: 50 3. Ontario Cereal Crops Committee: 25
4.	Number of new knowledge transfer products developed		
5.	Number of papers published in peer reviewed journals	8	1. Bai, J., Yan, W., Wang, Y., Yin, Q., Liu, J., Wight, C. and Ma, B., 2018. Screening oat genotypes for tolerance to salinity and alkalinity. *Frontiers in plant science*, *9*. 2. Bekele WA, Wight CP, Chao S, Howarth CJ, Tinker NA (2018) Haplotype-based genotyping-by-sequencing in oat genome research. Plant Biotechnol J 16:1452-1463. 3. Guo, W., Chen, Y.; Al-Rewashdy, Y., Foran, N., Ma, B.L., Yan, W., Frégeau-Reid, J. Liu, J., Ren, C., Pageau, D., Vera, C., and Xue, A.G. 2018. Effect of nitrogen fertilization on seed-borne Fusarium species in oat. Can. J. Plant Sci. 98: 38–46. 4. Li, P., Mo, F., Li, D., Ma, B.L., Yan, W. and Xiong, Y., 2018. Exploring agronomic strategies to improve oat productivity and control weeds: leaf type, row spacing, and planting density. *Canadian Journal of Plant Science*, *98*(5), pp.1084-1093. 5. Yan, W. and Frégeau-Reid, J., 2018. Genotype by Yield* Trait (GYT) Biplot: a novel approach for genotype selection based on multiple traits. Scientific reports, 8. 6. Sunstrum FG, Bekele WA, Wight CP, Yan W, Chen Y, Tinker NA (2019) A genetic linkage map in southern-by-spring oat identifies multiple QTLs for adaptation and rust resistance. Plant Breeding 138:82-94. 7. Zhao J, Tang X, Wight CP, Tinker NA, Jiang Y, Yan H, . . . Peng Y (2018) Genetic Mapping and a New PCR-based Marker Linked to a Dwarfing Gene in Oat (Avena sativa L.). Genome 61:497-503. 8. Blake VC, Woodhouse MR, Lazo GR, Odell SG, Wight CP, Tinker NA, . . . Sen TZ (2019) GrainGenes: Centralized Small Grain Resources and Digital Platform for Geneticists and Breeders. Database (in press).

Performance Measure		Results Achieved	Provide a brief description of each final result achieved during the reporting period.
6.	Number of new technologies (new products, practices, processes and systems) that are developed	2	1. GYT biplot analysis for genotype and management evaluation on multiple traits (published) 2. Rapture for genotyping
7.	Number of new technologies (new products, practices, processes and systems) that are assessed under research conditions		
8.	Number of new technologies (new products, practices, processes and systems) that are demonstrated on-farm or in-plant		

9.	Number of new technologies (new products, practices, processes and systems) that attain Intellectual Property (IP) protection.	1+2+4	• PBR for
			  o AAC Banner (SeCan)
			• Two new oat lines are in the process of being formally registered
			  o SeCan (OA1426-2 or AAC Clyde)
			  o SemiCan (OA1436-1 or AAC Roberval)
			• Four new oat lines have been supported for registration and tendered
			  o OA1453-2 (SeCan),
			  o OA1444-4 (SeCan),
			  o OA1415-2 (Eastern Grains),
			  o OA1568-6 (SeCan)

10.	Number of new technologies (new products, practices, processes and systems) that are utilized		

2. Activity-level Information

In this section, please complete one table for each activity. For activities with both a CA and CRDA component, please integrate the results into one table.

CA Activity Number: 1 / CRDA Activity Number: 1
Name(s) of Activity: Breeding, genomics and agronomy research to improve oat yield and quality
Principal Investigator:
Summary of Activity: Please provide a high-level summary of this activity that includes an introduction, objectives, methodology, deliverables, results and discussion. Technical language can be used in this section.
INTRODUCTION Oat is an important, multi-purpose cereal in Canada, which is grown for grain, straw, forage, or land cover. Oat grain is regarded as a healthy human food, largely due to the presence of oat beta-glucan (BGL) and other soluble fibers in the oat groat, which have been implicated in reduced risk of heart disease,

lowered blood pressure, and lowered risk of type-II diabetes. Grain yield, groat content (i.e. milling yield), and BGL content are key targets for improvement. Protein, test weight, and kernel weight are also secondary targets for improvement. Additionally, oat millers require a groat oil content of less than 8% to meet the FDA healthy food labeling requirements. To achieve high and stable yield and quality, lodging resistance is a key requirement for high-yielding environments, and resistance to crown rust is a key requirement in southern Ontario. Our nation-wide multi-disciplinary research team was assembled to improve these characters through conventional breeding, genomics, and agronomic studies. Expected impacts of this project on the Canadian field crop sector include: 1) increased income for Canadian oat growers, 2) increased profit for Canadian/American oat processors, 3) increased health of oat consumers in Canada and beyond, 4) increased resilience of Canadian agriculture against biotic and abiotic stresses and adaptation to climate change, and 5) enhanced Canadian soil and environmental conservation due to the planting more oats in rotation with other crops. Through these outcomes, this project addresses the following AAFC priorities: 1) to enhance Canadian environmental sustainability in the face of climate change, and 2) to enhance knowledge and technology transfer activities and thereby the resiliency and productivity of the agriculture.

OBJECTIVES

SIX objectives were planned in this project: **1**) to develop new oat cultivars with improved grain yield and quality (**Yan, Fregeau-Reid, Pageau, MacEachern, Mitchell-Fetch, Menzies, Xue, Mountain**); **2**) to identify optimal agronomic practices to achieve high and stable grain yield and quality (**Ma, Mountain, Pageau, MacEachern, Entz, Tidemann, Semach, Leach, Fregeau-Reid**); **3**) To enhance the current oat breeding procedures in both the Ottawa and Brandon programs with genomic selection (**Tinker, Yan, Mitchell-Fetch**); **4**) To screen advanced breeding lines for crown rust; **5**) to enhance information and germplasm exchange among North American oat breeding programs through a joint testing and genotyping network referred as ENCORE (**Yan, Mitchell-Fetch, Beattie**); and **6**) to develop a multi-faceted approach to data and knowledge management that enhances all objectives of this project and benefits world-wide pre-competitive oat research (**Tinker**).

METHODOLOGY

For Objective#1: Conventional methods that prove to work will be used. The breeding cycle includes 4 stages; namely, 1) parent selection and cross making, 2) generation advance, 3) visual selection at Ottawa, and 4) yield trials at multiple locations. At the last stage, yield, key agronomic traits, grain quality, compositional quality traits are determined, and diseases nurseries were planted to select for resistance to crown rust and other diseases.

For Objective#2: Six Nitrogen fertilizer (N) levels were applied to three oat cultivars at each of the following locations, with four replications in a research scale: Ottawa ON, New Liskeard ON, Normandin QC, Melfort SK, and Beaverlodge AB. In addition, a production scaled study was conducted at Winnipeg MB. The following measurements and samples are taken: Soil samples (pre-plant, jointing, post-harvest), phenological stage notes, stand counts, Belgian lodging score, plant height, yield components, harvest index (HI), plot grain yield and moisture, test weight and kernel. Harvested grain maples are determined for grain and compositional quality weight (protein, oil, groat and beta-glucan).

For Objective #3 This objective includes four aspects: 1) phenotypic data acquisition, 2) molecular data (genotypic data) acquisition, 3) genomics model development, 4) GS prediction. Phenotypic data were obtained in conjunction with the first-year yield trials ("Home Test"), in which about 400 lines were tested for yield and other traits at Ottawa, Normandin, and New Liskeard, with two replications each. Genotypic data were obtained by GBS or an improved vision. GS model were developed using the phenotypic data from the 2015, 2016, and 2017 Home Test and ENCORE test at Ottawa (inclusion of data from other sites have been discussed and planned). Predictions were made for 1400 individuals from 10 crosses that were not subjected to any selection. 60 GS-good lines and 20 GS-poor lines out of these, along with 60 visually selected lines from the hills of the same crosses were increased in NZ in winter 2018, which will be tested and compared in the 2019 Home Test.

Objective#4 Screening for crown rust resistance and crown rust survey for about 500 lines tested in the yield trials at Morden MB and Heckston ON

Objective#5 A total of 165 new breeding lines from three oat breeding programs (AAFC-Ottawa, AAFC-Brandon, and University of Saskatchewan) were tested at 4 locations with two replications each (Ottawa, Brandon, Saskatoon, and Lacombe). Yield,. Agronomic traits, and quality traits at two sites are determined.

Objective#6: Charlene Wight, the new biologist at AAFC, under Dr. Tinker, is in charge of Oat Data and Knowledge Management. She attends weekly meetings (via videoconference) with both the T3/Oat and GrainGenes teams. A new curation tool, developed by Dave Matthews of the USDA, is used to update pedigree information in POOL and T3/Oat at the same time. She has also been working with Victoria Blake of the USDA to format mapping data for uploading to the GrainGenes database. In addition, Charlene edits the Oat Newsletter.

DELIVERABLES

Objective #1: Cultivar development (yearly)

- About 50 new crosses
- About 300 F4:5 or F6:7 lines, to be tested in next year's Home Test.
- Yield and quality data of c. 400 breeding lines from Home Test.
- Yield and quality results of c. 60 breeding lines tested in the Preliminary Test.
- Yield and quality data of c. 30 breeding lines tested in the registration test.
- Up to 2 oat lines supported for registration

Objective #2: Agronomic research to develop oat production guide

- 2018/2019: Data and summary of the 1st year Exp1.

Objective #3: Genomic selection

- GBS markers for about 2000 new breeding lines (about 1000 from each of Ottawa and Brandon);
- 900 lines from training population genotypes were phenotyped, added to database, and used to update GS predictions for both breeding programs.
- 80 lines from each of Ottawa and Brandon selected based on GS and increased in New Zealand

Objective #4: Crown rust survey (annually)

- Report on the crown rust rating of the oat crown rust differential lines tested in Ottawa and Morden
- Report Survey results of oat field in eastern Canada and western Canada
- Report of reactions of key oat cultivars and promising lines to different crown rust races

Objective #5: North American joint oat breeding and testing (ENCORE)

- Yearly data of grain yield, agronomic traits, grain quality traits, and diseases for c. 240 new breeding lines from 4 breeding programs at 5 locations and compositional quality from at least one location.
- Genotypes and phenotypes of ENCORE are incorporated to train and evaluate GS.

Objective #6: Oat Data and Knowledge Management

- 2018: Formal linkages and curational arrangements with T3/Oat, GrainGenes, ORI, and POOL.
- 2019: POOL is up-to-date with recent germplasm from major North American programs and queries in POOL provide a gateway to relevant data in T3/Oat and GrainGenes.

RESULTS AND DISCUSSION

Objective#1

- 48 new crosses were made in Feb 2019
- About 13000 lines were grown in the hill nursery and 1000 were selected to go to the 2019 observation nursery
- About 800 lines were grown in the observation nursery and 238 lines were selected to enter the 2019 Home Test
- 408 oat lines (including 27 GS-selected good lines, 12 GS selected poor lines, and 30 common checks, and 238 breeding lines) were tested in the Home Test at three locations. 55 lines were selected to enter the 2019 ENCORE/preliminary test. Yield and quality data were used in GS model development.
- 17 lines were selected from the 2018 Preliminary/ENCORE test to enter the 2019 registration test
- 4 oat lines were supported for registration and tendered by seed companies

Objective#2:

- In this first year of the study, Experiment 1 was conducted in which three oat cultivars were tested with six nitrogen (N) fertilizer treatments. Due to the delayed budgetary decisions and challenging weather circumstances, the Regina, Saskatoon and Lacombe sites did not run the experiment in 2018. The Winnipeg site is in the process of aggregating its data and is not presented in this report.
- The trial consisted of a 3 x 6 factorial experiment arranged in a split-plot design with 4 replication. Nitrogen is the main plot and oat cultivar is the subplot. Nitrogen treatments were applied as preplant urea (46-0-0) at the following rates: 0, 40, 80, 120, 140, 180 and 200 kg ha-1. Three region appropriate cultivars were used at each site. In Eastern Canada: Nicolas, Akina and CS Camden, and in Western Canada: Summit, Souris and CS Camden. Soil test (0-15 cm) samples were taken through the fields prior to planting, and P and K fertilizers were added according to provincial guidelines at each site.
- The following measurements and samples were taken: Soil samples (pre-plant, jointing, post-harvest), phenological stage notes, stand counts, Belgian lodging score, plant height, yield components, harvest index (HI), plot grain yield and moisture, test weight and seed quality determination (protein, oil, groat and beta-glucan). As analyses of 2018 samples are ongoing, this preliminary report focuses on yield and lodging data.
- In general, sites experienced drier than usual early to mid-season, leading to decreased yields and increased variability. No lodging was observed at any of the study sites. Strong and statistically significant ($p<0.05$) N responses were observed at the Melfort and Beaverlodge sites, with weaker responses at the remaining sites. At the Ottawa site few N treatments were statistically different due to variability, yet in two (Akina and CS Camden) of the three cultivars, treatment averages responded to increasing N in the lower rates. There was a lack of responses of cultivar yields to N treatments, likely due to legume (clover) as the preceding crop at Normandin and small plot size (and likely erratic rainfall) at New Liskeard sites. No statistically significant cultivar x N treatments interactions were observed. In general, the most effective rate of nitrogen in terms of yield appeared to be in the 80 - 120 kg ha-1 range, based on the Ottawa, Melfort and Beaverlodge

sites. In following years, the maximum economic rate of nitrogen (MERN) will be determined.

Objective#3:

- Phenotypic data were obtained for 408 oat lines from the 2018 Home Test and 165 oat lines from the 2018 ENCORE.
- Total Number of lines used in training models = 1807 (2015-17 Home test and ENCORE)
- Total number of lines screened by GS in 2018-19 = 1140 + 409. Traits predicted were: Yield, beta-glucan, and resistance to crown rust.
- 60 GS predicted top lines and 20 GS predicted bottom lines, along with 60 lines visually selected in the field were increased in New Zealand. They will be part of the 2019 Home Test.
- A new genotyping method called "Rapture" was designed and tested. This is based on the previous GBS method, but uses an additional enrichment step based on enriching for 10,000 selected markers to increase the reliability and decrease sequencing cost. Preliminary results were promising, and the technology will be used in the 2019 screening season. The result will compensate for increased sequencing costs with no overall impact on the project, and may allow a larger number of lines to be tested than what was originally proposed.

Objective#4

- 500 oat lines were screened at Morden MB for crown rust and smut and Heckston ON for crown rust
- Surveys on oat crown rust in east and west Canada is in press in the journal of Canadian Plant Disease Survey.

Objective#5:

- 165 new breeding lines from AAFC-Ottawa, AAFC-Brandon, add U Saskatchewan were tested at 4 locations (Ottawa, Brandon, Saskatoon, and Lacombe). Yield, agronomic, and quality data from 4 locations were obtained and used in decision making in respective breeding programs and in GS model development.

Objective#6:

- 4,236 pedigrees were added to or edited in POOL-T3/Oat.
- 44 genetic maps and associated genes/QTL (mostly for rust resistance) were submitted to GrainGenes.
- Twelve updates were made to the Oat Newsletter. Update notifications are being made via email to a subscriber list and through Twitter (@OatNewsletter – currently with 1206 followers). An "OatMail" Listserv was also established.

Issues:

- Describe any challenges or concerns in achieving the results and deliverables of this activity during the reporting period. How were they overcome or how do you plan to overcome?
- Describe any potential changes to the work plan and the budget during the reporting period. How were or how will they be managed?

1) For Objective#5: North Dakota State University was not able to contribute lines to ENCORE due to a drought spell in the previous year. The test from other three programs was grown at Fargo but no data were submitted due to personnel change. No funding was associated with this objective—the cost is to be absorbed by each participating program. The loss of NDSU will affect germplasm and information exchange between the three Canadian programs and NDSU. One remedy is to more closely look into the midseason oat nursery and other collaborative trials that we grow. It is hoped that NDSU will come back when their oat personnel are stabilized.
2) For Objective#2, Jim Dyck withdrew from the agronomic study team due to reduced budget. Mike

Hall from Yorkton SK is to fill this vacancy starting in 2019.

3) For Objective#2, no experiment was conducted at the Lacombe and the Regina sites as planned, due to late approval of the project. All planned locations will be operated in full capacity in the coming year.

Key Achievements:

A key achievement represents a significant achievement or tangible result that could potentially be applied either by farmers or industry or the science community. In one to three paragraphs, please provide key achievements that meet one of the following criteria:

1) The item has commercial potential (all testing and piloting has been completed);
2) The item has been commercialized; or
3) The item has been adopted by the sector.

Examples of tangible results could include increased sustainability (beneficial management practice), reduced costs, improved productivity or increased profitability. Please note that the information provided will be used for communication purposes only.

If no key achievements have been realized at this stage, please leave this section blank.

- **4** new oat lines have been supported for registration and are tendered, they are **OA1453-2** (SeCan), **OA1444-4** (SeCan), **OA1415-2** (Eastern Grains), and **OA1568-6** (SeCan). They were selected to adapt to the two contrasting subregions of eastern Canada: **OA1453-2 and OA1444-4** have superior crown rust resistance, governed by different resistance genes, and are more adapted to southern Ontario; **OA1415-2 and OA1568-6** have improved yield and beta-glucan levels and are more adapted to northern regions of eastern Canada. **OA1444-4** has a rare combination of superior crown rust resistance and BYDV resistance, high groat content, and high beta-glucan content, good lodging resistance, and high yield, particularly in the rust-prone regions.
- The **GYT biplot analysis** (Yan and Fregeau-Reid, 2018) has become an important tool for our breeding program and is expected to find wide application by other plant breeders for making selection decisions based on multiple traits.
- The **Rapture** procedure showed promising as a new generation of genotyping by sequencing (GBS).

Annex A

Performance Measures Table	
Performance Measures	**Description**
1. Number of highly qualified personnel (HQP) working on funded activities	This includes individuals who are registered in Master or PhD programs and are working on activities that receive funding through the Canadian Agricultural Partnership. They are only counted in their first year working on projects. For each reported HQP, please provide the following: the name of the student, level of degree, field of study and name of the academic institution.
2. Training/knowledge transfer events	
2.1. Number of training/knowledge transfer events organized	This includes events completed in the reporting year that were organized under the project to share results of the activities with audiences who may use that knowledge in the future. Examples could include training events, scientific meetings, symposia, conferences, workshops, industry meetings, field days or webinars. For each reported item, please provide the following: name of the event, name of the organizer and organization, location, and year/month/day.
2.2. Number of presentations made in training/knowledge transfer events	Examples of events could include, but are not limited to conferences, symposiums or training events. For each reported item, please provide the following: name of presenter, title of presentation, name of the event, location, and year/month/day.
3. Number of participants at training/knowledge transfer events	This includes individuals who attend the events listed and who may use that knowledge in the future.
4. Number of new knowledge transfer products developed	New knowledge could include, but is not limited to: 1) newly acquired knowledge that differs significantly from previously acquired knowledge; 2) existing knowledge that is enhanced to meet different requirements; 3) existing knowledge that is applied in different situations. These are knowledge transfer materials created under the project that have been disseminated to transfer information to audiences who may use that knowledge in the future. Examples could include brochures, factsheets, flyers, guides, articles in trade magazines, technical bulletins and social media items. Only the number of products developed should be reported, not the number of copies that were printed and disseminated. For each reported item, please provide the following: author(s), title of the item, type of the reported item (e.g. brochure), name of the trade magazine/publisher and page number(s) if applicable, and year/month/day.
5. Number of papers published in peer reviewed journals	This includes scientific papers that are published in peer reviewed journals. Papers that are not yet published (ex. manuscripts in preparation, under review or accepted) should not be reported. For each reported item, please provide the following: author(s), year of publication, article title, title of journal, volume (issue), and page number(s).

	If the item is a book or a book chapter, add name of publisher. If the item is an article for conference proceedings, add title of published proceedings, location, and year/month/day.
6. Number of new technologies (new products, practices, processes and systems) that are developed	A new technology could include, but is not limited to: 1) a newly created technology that differs significantly from existing technologies; 2) an existing technology that is modified to meet different requirements; 3) an existing technology that is tested in different situations. New products are goods and services that differ significantly in their characteristics or intended uses from products previously produced and used. Examples could include equipment, software, novel foods or consumer goods. New practices are new agronomic techniques or methods that can be applied directly by producers. New processes are the set of operations performed by equipment in which variables are monitored or controlled to produce an output in labs or processing facilities. New systems are the set of detailed methods, procedures and routines created to carry out a specific activity, perform a duty, or solve a problem. Development consists of the creation of a new product, the generation of a new practice, or the demonstration of utility of a new process or system. To avoid duplication, for any new technologies, only set a target that represents the last stage in the innovation process. For example, a new technology is either developed, or assessed, or demonstrated or utilized.
7. Number of new technologies (new products, practices, processes and systems) that are assessed under research conditions	See the definition of new technologies under #6. Are assessed: when new technologies are evaluated or tested under research conditions. To avoid duplication, for any new technologies, only set a target that represents the last stage in the innovation process. For example, a new technology is either developed, or assessed, or demonstrated or utilized
8. Number of new technologies (new products, practices, processes and systems) that are demonstrated on-farm or in-plant	See the definition of new technologies under #6. Are demonstrated: when new technologies are presented to the sector by experiments, prototypes, examples or pilot on-farm or in-plant. To avoid duplication, for any new technologies, only set a target that represents the last stage in the innovation process. For example, a new technology is either developed, or assessed, or demonstrated or utilized.
9. Number of new technologies (new products, practices, processes and systems) that attain Intellectual Property (IP) protection	See the definition of new technologies under #6. Examples for IP protection could include, but are not limited to: plant breeder rights, patents filed, registered trademarks and copyrights, and registered or released varieties. For each new variety, please provide the registration number, the variety name, and year/month/date.

10. Number of new technologies (new products, practices, processes and systems) that are utilized	See the definition of new technologies under #6. Are utilized: when new technologies are adopted or implemented for use within the sector. Examples may include, but are not limited to: a signed license agreement, a signed letter of intent, a new product that is available on the market, and a new practice which is adopted by farmers. To avoid duplication, for any new technologies, only set a target that represents the last stage in the innovation process. For example, a new technology is either developed, or assessed, or demonstrated or utilized.