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CROP IMPROVEMENT AND SUSTAINABLE PRODUCTION SYSTEMS

NON-TECHNICAL SUMMARY: This Hatch Umbrella Project seeks to enhance sustainability and profitability of production systems for important crops in Washington State, regionally and nationally. Participants will pursue a collaborative, multidisciplinary strategy bringing together expertise in plant breeding, crop physiology and rapidly-advancing areas of genomics, phenomics and bioinformatics, complemented by extension activities in outreach and stakeholder engagement in apple, blueberry, grape (juice and wine), pear, potato, raspberry, sweet cherry, strawberry, and wheat. Our approach is to combine disciplinary strengths in high-throughput genotyping, quantitative and statistical genetics, bioinformatics and physiology with plant breeding, to support diverse crop improvement programs and maximize our impact on cropping systems, farm profitability, rural livelihoods, and food security.Over 200 different annual and perennial crops are produced in Washington across highly variable irrigated and rain fed systems on 37,000 farms distributed statewide. Annually, the state's food and agriculture industry is valued at $49 billion, constituting 13% of the state's economy and employing approximately 160,000 people. The project focuses on crops of major importance in Washington: berries, grapes, potato, tree fruit, and wheat.Agriculture in the U.S. requires the development of efficient, sustainable crop production systems that help solve existing and emerging biotic and abiotic threats, thus enhancing farm profitability, rural livelihoods, food security, and environmental stewardship. Such systems require genotypes that are optimally adapted to their production environments and readily accessible to primary producers. Development and delivery of superior genotypes demands a collaborative, multidisciplinary approach, bringing together expertise in plant breeding, crop physiology, genomics, phenomics and bioinformatics and effectively complemented by extension activities in outreach and stakeholder engagement.

OBJECTIVES: The project proposes four objectives aligned with each of the four activity areas:1. Develop and advance genomics, phenomics and bioinformatics knowledge and resources applicable to crop improvement via plant breeding, biotechnology and crop physiology.2. Increase efficiency and effectiveness of plant breeding programs to develop and deliver superior, resource-efficient cultivars.3. Enhance physiological understanding to mitigate biotic and abiotic stress,

formulate specific best management practices that promote on-farm efficiencies, and enhance product quality and yield, pre- and post-harvest.4. Engage with project breeding programs and stakeholders to hasten cultivar adoption and implement best management practices for sustainable and profitable crop production.

APPROACH: Organizationally, participants are grouped into four areas of activity: Area 1 - Genomics, phenomics and bioinformatics; Area 2 -Plant breeding and Genetics; Area 3 - Crop Physiology; Area 4 - Extension, Outreach and Stakeholder engagement. Operationally, many work across these areas.Activity area #1.1 Development of database resources for basic discovery and crop improvement. Key personnel: Main.The Tripal Breeding Information Management System will be further developed to provide upload, edit, and analysis capability. Publicly available genomic, genetic and breeding data will be curated and integrated in GDR and CSFL, with new tools developed as needed by researchers.2 Computing pipeline for mapping genes and molecular breeding. Key personnel: ZhangInteractions among genetic effects, including additive, dominant, and epistatic effects and interactions between genetic and environmental effects will be modelled and implemented into existing computing pipelines. Statistical models will be examined with programming in R language.3 Plant Genomics and Biotechnology. Key Personnel: DhingraPhenological, physiological (preharvest and post-harvest), developmental and, biotic or abiotic stress models will be developed or adapted from prior publications for application of genomics approaches to identify genes of interest. These approaches will include genome sequencing, comparative analysis, RNAseq etc. Gene overexpression, antisense, knockouts, knockdowns and genome editing will be used for validating gene-trait relationships in reverse genetics approaches.Activity Area #2.1 Pome fruit breeding and cultivar development for Washington State. Key personnel: EvansDNA-informed breeding will be used to supplement traditional breeding and selection decisions to combine parents and identify potentially superior apple seedlings early. Pear rootstock seedlings will be budded in situ with a standard scion cultivar to determine their vigor control and precocity.2 Potato cultivar development. Key personnel: Knowles, PavekClonal selections will be evaluated for adaptability and production potential in the high temperature, long growing season areas of WA. Field trials will identify growth and development characteristics of recently released cultivars. Storage, processing, and culinary characteristics of clones across all trial will be analyzed.3 Wheat breeding for Washington State. Key personnel: Carter, Jones, PumphreyTraditional and molecular breeding approaches are used to develop new wheat cultivars for Washington State. Modified bulk-pedigree and backcross breeding schemes are most commonly employed. Cross-hybridization and doubled-haploid technology is used to develop new breeding lines. High-throughput phenotyping allows for selection on traits that was not possible only a few years ago.4 Berry breeding for Washington State. Key personnel: MooreTraditional breeding methods will be used with parents selected based on performance and their pedigrees. Promising selections will first be evaluated in unreplicated plots. The most promising selections will be evaluated in replicated plots and potential releases will be evaluated in grower trials.5 Stone fruit breeding and cultivar development for the Pacific Northwest. Key personnel: PeaceDNA-informed breeding will be used to supplement traditional breeding and selection decisions to combine parents and identify potentially superior apple seedlings early. Fruit of bearing seedlings raised in the breeding orchard will be evaluated for some key traits in the orchard, then evaluated for further traits indoors before and after refrigerated storage, using both sensory and instrumental methods.6 DNA-informed breeding capability for WSU's tree fruit breeding programs. Key personnel: PeaceThe principles of translational genetics will be followed, with focus on (1) establishing and enhancing breeder desire for use of DNA information, (2) adapting tools to local breeding utility, (3) identifying efficient application schemes within breeding programs, (4) accessing effective services in DNA-based diagnostics, and (5) ensuring breeding programs gain experience in conducting routine analysis.Activity Area #3.1 Improving pollination and fruit set in blueberry. Key personnel: DeVetterData on alternative pollination strategies are

primarily collected from commercial grower cooperator fields in northwest Washington. Measured variables include modified honey bee hive densities, supplementation with alternative pollinating species (e.g. Bombus spp.), and application of pheromones. Abiotic parameters of the environment and their role in modifying fruit set are also being evaluated, including mineral nutrition and carbohydrate resources as impacted by solar radiation.2 Grapevine physiology. Key personnel: Keller, BondadaField trials involving deficit irrigation strategies will be conducted in a WSU Roza vineyard (Prosser, WA). These strategies include partial rootzone drying (PRD) and regulated deficit irrigation (RDI), commonly used in an arid environment to conserve water. Also, mechanized pruning and crop thinning will be compared with manual pruning in a commercial vineyard.3 Potato: Augment the Pacific Northwest Potato Variety. Key personnel: Knowles, PavekAgronomic performance will be evaluated under low-input production conditions with innovative planting designs to optimize land use efficiency. Genotypes that are tolerant of heat, water and nutrient stress will be selected for further work to develop best management practices (BMP).4 Optimization of fruit quality. Key personnel: Musacchi, SerraA randomized block trial at WSU-Sunrise Orchard (Wenatchee) planted in 2013 to assess WA 38 grafted on two rootstocks, M9-Nic 29 and Geneva 41, will be used to compare two training systems, spindle and V, with planting densities of 1,499 and 2,997 trees/acre, respectively.5 Affecting elemental uptake and distribution in tree fruit. Key personnel: KalcsitsApproaches will include applied experiments related to soil nutrition, foliar nutrient application, crop load, and irrigation. More basic experiments will target the contributions of xylem and phloem water to fruit development and elemental distribution, developadvanced phenotyping approaches and integrate tracer approaches into experiments using contrasting environmental, and genetic scenarios affecting mineral uptake and distribution.Activity Area #4.1 Improve horticultural practices in Berry. Key personnel: DeVetterData on adoption and preferred outreach mechanisms will be collected through focus groups and surveys conducted at regional meetings, field days, and conferences.2 Improve horticultural practices in potato. Key personnel: PavekMock contract models will be used to estimate potential returns for fresh and processed markets. Information from these analyses will be distributed at potato field days, annual Workshop, WA/OR/ID annual conferences, national and international conferences and annual Tri-State and Western Regional Technical Committees. Written publications will be available via popular press media, peer-reviewed journal articles, the WSU Annual Potato Cultivar Summary Book, extension bulletins, and electronically (www.potatoes.wsu.edu).3 Engage with project breeding programs and stakeholders to hasten cultivar adoption and implement best management practices for sustainable and profitable tree fruit production. Key personnel: McFersonCoordinate individual activities with TFT based on annual strategic planning, monthly to Methods described above should reduce this risk. Team meetings, and ongoing communication and education via print and electronic media, trade association meeting and small group setting.Regional and national/international activities will be pursued. Efforts will be made to engage primarily Spanish-speaking audiences and ensure participation across the wide geographic and socio-economic status of stakeholders.

KEYWORDS: breeding; genetics; genomics; phenomics; bioinformatics; crop physiology; wheat; potato; grape; apple; cherry; small fruit; best management practices