

ANNUAL PROGRESS REPORT

For Calendar Year 1993

USDA-ARS
NATIONAL CLONAL GERMPLASM REPOSITORY
33447 Peoria Road
Corvallis, OR 97330

Presented July 5 and 6, 1994
Pullman, WA

Dr. Kim Hummer, Research Leader/Curator
Dr. Barbara Reed, Cryopreservation, Plant Physiologist
Bruce Bartlett, Agricultural Technician-Greenhouses & Distribution
Brian Courtney, Computer Specialist Trainee
Judith Flynn, Secretary
Jeanine DeNoma, Biological Technician-Tissue Culture
Ray Gekosky, Agricultural Technician-Fields
Lisa Hunt, Agricultural Technician-Screenhouses & Acquisitions
Carolyn Paynter, Biological Technician-Tissue Culture
Joseph Postman, Plant Pathologist
Joe Snead, Agricultural Technician, Field Manager
Dennis Vandever, Facilities Manager

Dean Harrison, Student Worker (Temporary)
Kim Hendricks, Biological Aid (Temporary)
Patrick Hund, Agricultural Aid (Temporary)
Matt Johnson, Student Worker (Temporary)
Joey Ratliff, Student Worker (Temporary)
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Mohan Kumar, Graduate Student
Jie Luo, Graduate Student
Wes Messinger, Graduate Student
Derek Peacock, Graduate Student
Piyarak Tanprasert, Graduate Student

Dr. Henrietta Chambers, Collaborator
Dr. Francis Lawrence, Collaborator
Dr. Maxine Thompson, Collaborator

PERSONNEL

Kim Hummer

Several of our permanent staff members resigned in 1993. Mr. Bill Doerner, our valued Agricultural Science Research Technician who was in charge of integrated pest management, has joined the Maryknoll Lay Mission Program and has begun an assignment in Thailand. Pest management responsibilities have been reassigned to staff members in charge of the greenhouse, screenhouse and field facilities.

Mr. Dennis Magnello, who worked for us for about a year in the greenhouses and filling plant distribution requests, resigned in August. In November we hired Dr. Bruce Bartlett to fill this replacement. Bruce has been taking on the plant requests with gusto. We are extremely happy to have him on board.

Mr. Jay Goodwin, our seed technician, resigned to assume a graduate program at Utah State University. Unfortunately, since funding is limited we made the difficult decision not to replace this position. Jay established a seed laboratory for us. He was beginning to get our seed collection in adequate shape. At present the seeds are stored at -20C and much work remains to bring the collection to adequate condition.

Because of a tight funding and fixed FTE ceiling we had to terminate the part-time appointments for three visiting scientists. Dr. Maxine Thompson, Dr. Henrietta Chambers, and Dr. Pat Buckley. Both Drs. Thompson and chambers are finishing their projects as unpaid collaborators. Dr. Buckley has recently accepted a position at Microplant Nursery, Gervais, Oregon and will continue to work with reduction of bacterial infection of in vitro cultured plants.

With suggestions from our NCGR Technical Committee Meeting in October 1993, we have revised our staffing plant. Joe Snead has been designated as our Plant Production Manager to supervise plant movement through greenhouse, screenhouse, shadehouse, and field. Lisa Hunt, our greenhouse manager, and Ray Gekosky, our field technician are under his supervision. Joseph Postman has been designated to supervise the plant information management, including Brian Courtney, our student Computer-Trainee, and Bruce Bartlett, our Plant Distribution Technician. Our in vitro culture technician, has now been assigned half-time responsibility to assist in the virus testing laboratory.

BUDGET AND OPERATIONS

Kim Hummer

Our base funding has been essentially level since 1989. Our two CRIS projects totaled \$679,453 for FY 1993. We received \$130,782 of extramural funding in FY 1993 including money for specific cooperative agreements, fuel tanks for north farm, *Rubus* evaluation, training of Indian scientists, and student assistants. Because of budget limitations we have begun the following cost saving measures planned for FY 1994:

Reduction in staff

- We have eliminated the 3 part-time visiting scientist positions.
- We did not replace a biological technician position.

Reduction of on-site redundancy

- We have removed the *Ribes* screenhouse collection.
- We have removed the *Fragaria* field cultivar collection.
- We have removed the *Rubus* field cultivar collection.
- We have reduced the mint collection to 1 pot per plant (except for the core collection.) The in vitro mint collection will be reduced through attrition to members of the core collection.

PHYSICAL PLANT

Dennis Vandever

We installed a new washer and dryer to keep up with new pesticide regulations. In October a new bio-therm was installed. Three offices were remodeled in the head house. The interior of the headhouse was repainted and new swamp coolers for greenhouse #3 were purchased.

In an effort to control the heating and cooling in the growth room a new climate control system was installed. This system isolates the room from the rest of the building and provides for a constant 20°C. and a controlled level of humidity. The lighting in greenhouse #1 and #2 were improved upon utilizing numerous high pressure sodium fixtures controlled by timers and individual switches.

The fire alarm system has been upgraded and now each greenhouse has fire alarm strobe horns. One horn was installed at the rear of the headhouse to alert personnel working in the screenhouses and pole barn.

Work on the North farm pre-engineered building is underway. The concrete slab was poured as a mono slab construction using a fiber filler. The main steel frame pieces were set into place and the walls were framed to accommodate five windows for extra light and to conserve energy. We will be installing the metal roof and sides as work permits this spring. When complete, the building will include a rest room, office area, three bays for equipment storage, a ventilated pesticide storage cabinet and fume exhaust system for welding operations. Also, two new above ground fuel tanks were installed. One at the new farm for diesel storage and one at the main complex for gasoline storage.

ACCESSIONS STATUS

Kim Hummer and Joseph Postman

Each year the number of active accessions at the Repository has increased. The number of accessions and the virus status can be found in the attached figures.

We have a post-entry import permit from APHIS and have been granted several APHIS departmental permits for plant importation from foreign sources. To date the Repository 674 accessions have been released by APHIS from on-site quarantine and incorporated into the domestic collections. At the end of 1993, 137 accessions were being maintained under post-entry and other quarantine at the Corvallis Repository.

We expect that our accessions of several genera will be increasing although the numbers for some of our genera have stabilized. We anticipate that the collections of small fruits genera, *Fragaria*, *Ribes*, *Rubus*, and *Vaccinium*, particularly species, will continue to increase. We are actively seeking several hundred primarily foreign cultivars. The *Pyrus* and *Corylus* collections will

increase but more slowly than the small fruits. Both of these genera are fairly well represented in our collections considering world distribution and cultivar development.

CORE COLLECTION ESTABLISHMENT

Kim Hummer

Recently, the Associate Deputy Administrator for Germplasm, Dr. Henry Shands, requested that all sites establish "core" collections for their major crops. The Corvallis Repository is responding to this request in the following manner. In October, the NCGR-Corvallis Technical Advisory Committee met in Corvallis. Subcommittees were formed to review each of the major eight genera to designate accessions as members of the "core." These designations will be reviewed by the Curator and by Small fruits and Pyrus Crop Advisory Committees, and by other specific crop experts.

Members of the core collections will be designated in the local database and on the Germplasm Resources Information Network (GRIN), the national system. A reason why the accession was chosen as a member of the core will also be entered. Ideally, the core collection will encompass the diversity of the genus and the cultivated forms as efficiently as possible. The core may distributed for research projects needing a diversity of samples. The core collection will be given priority in identity verification, virus testing, in vitro culturing, on-site, and remote-in-the-system backup locations (such as at NSSL). Back-up of non-core accessions will be sought at remote non-system sites, such as arboreta, botanical gardens, private or hobbyist collections.

Thus far, members of the core collections are under review. Initial designations for the core lists for *Corylus*, *Mentha*, and *Ribes* have been prepared. Those for *Fragaria*, *Pyrus*, *Rubus*, *Vaccinium* are under discussion.

COMPUTER INFORMATION AND GRIN INTERFACE

Kim Hummer and Brian Courtney

Our unit works with a Novell Netware 3.11 local area network. We have 9 nodes including the following hardware:

<u>Number</u>	<u>Type</u>
1	PC compatible 486
4	PC compatible 386
4	PC compatible 286
3	Laser printers

Our main local database uses Foxpro 2.6. Our text editing programs include Word Perfect 5.1 and Microsoft Word for windows. Accession, inventory, order processing, and cooperator data is uploaded to the GRIN system quarterly. Evaluation information is uploaded to GRIN as filed become available.

PLANT DISTRIBUTION

Bruce Bartlett

The NCGR in Corvallis continues to distribute plant germplasm within the United States and internationally. To date we have distributed 1,935 items for 1993 requests. This represents 77% of the total items requested (2,524). There were 287 orders for 1993, lower than the 358 recorded from 1992. For 1994 the current rate of new orders suggests we may end up with a similar number to 1992.

The plants that we shipped in 1993 required 70 USDA phytosanitary certificates (PC), which we obtained through our state inspector. We expect that we will be providing 90 PC in 1994. Our state inspector will begin charging \$10 per PC in 1994. We must give 2 to 4 weeks notice to obtain PC through the state. If we have an immediate need for a PC we can contact Seattle or Portland APHIS stations who will provide a PC for \$19.00 if we ship the plants to them through overnight delivery services.

The diverse nature of plant accessions at NCGR-Corvallis presents an ongoing challenge to quickly fill requests. Items may be pending for as long as three years. The coordination of foreign import permits, seasonal availability, and slow plant growth contribute to delays in shipping. Sixteen percent of 1993 requested plants are either not available or canceled and 7% still remain pending. Ultimately, 85% of 1993 requested items will be shipped.

There were 226 orders (79% of the total) from U.S. requestors representing 1,811 items (72% of the total). Foreign requestors placed 61 orders (21% of the total) representing 713 items or 28% of the total. Foreign requestors therefore asked for more items per order than their U.S. counterparts. Foreign requestors reported a higher percentage of spoiled plants upon arrival. The cause is clearly the long time interval in transit. Domestic requestors receive plant items within three days of mailing. Packages sent airmail to foreign requestors may take up to six weeks. We continue to work with all requestors in improving shipping methods.

To date \$826 has been spent on postage for 1993 requests. This figure should rise to \$900 for still pending requests before 1993 is closed. In 1992 \$1,254 was spent on postage and the rate at which new requests are being received, postage for 1994 should be similar to 1992.

Accessions of *Fragaria*, *Pyrus* and *Rubus* were the most often requested in 1993 (see figure below). Approximately 1,000 fewer items were requested in 1993 than in 1992. The reduction in items requested was similar in all genera except for *Pyrus* which showed a much smaller drop.

PLANT MAINTENANCE

Greenhouse and screenhouse notes

Lisa Hunt

In the summer an effort was begun to improve the primary collections of small fruit maintained under screen. A new fertilizing regime was instituted which is more suited to the specific plant requirements and costs less.

We installed a new Davis solar misting controller for our mist beds. This is not a digital display so it is easy to read and to program. It does not lose its memory when the power goes out. It can be set to come on by the amount of sunlight intensity or by time. We liked it so much we bought

a Davis irrigation controller for our screenhouses when the old controller quit.

Corylus: In 1993, 48 new hazelnut accessions were acquired, some of which were replacement plants for trees that died. Most arrived as scions. Of these 48 accessions, 6 have been planted in the field, 7 died, 17 are still in quarantine, and the remainder are still in propagation as layering was not done in time to produce self-rooted plants for the field. Our policy is to plant only self-rooted trees in the field so that field layering can be done from the suckers produced by the trees and no mistakes will occur from having a different rootstock.

Fragaria: The strawberry collection has expanded to 1.5 screenhouses. We have consolidated the strawberries from Chile in one location since they require specialized care.

Pyrus: In 1993, we produced 205 grafted virus free Pear accessions which will be planted in the field.

Ribes: Many softwood cuttings were rooted in the summer of 1993 in preparation for the field collection. The Ribes were removed from the screenhouse and the primary collection is located in the field.

Rubus: The field cultivar collection was eliminated the fall of 1993. Before it was taken out several cuttings had to be taken to maintain accessions that were not in the screenhouse collection. Cuttings of raspberries, blackberries and a few species were taken in the late summer and placed under mist in the greenhouse. All of the accessions rooted, however, two of them died after potting and crowns had to be dug from the field for replacement plants. We would like to do some rooting trials with the raspberries to see what kind of rooting success we can expect from our screenhouse collection at different times of the year. Our current method of propagating raspberries now is to collect crowns or rhizome cuttings. If we can root cuttings successfully it would save us labor in the future.

Vaccinium: Hardwood cuttings collected and wounded in January of 1993 were stored in the freezer with moist paper towels at close to freezing temperatures until early May when they were placed under mist. Many of them died when they leafed out due to the misting interval not set to come on frequently enough so no data on rooting success was taken. Many did very well and several old plants have been replaced in our screenhouse collection. We are trying again this year and hope to get data on rooting success. Most of the *Vaccinium* has been moved from the screenhouse to the field, where the primary collection now resides. Only the cultivars remain

Integrated Pest Management (IPM) 1993

Lisa Hunt

We had several outbreaks of aphids in the greenhouses during the growing season, probably due to the weeds growing around the greenhouses near the swamp coolers. We had a very hard time scheduling herbicide applications in the spring and early summer of 1993 due to the cool, rainy weather conditions we had here. Eventually, weeds around the screenhouses and shadetubes were controlled late in the growing season so that only one instance of aphids occurred in one screenhouse early in the summer. Because of our virus cleanup program and the susceptibility of some of our genera to aphid-vectored viruses we have a zero tolerance level for aphids.

In previous years we received monthly shipments of the parasitic wasp, *Encarsia formosa*, to control greenhouse whitefly through October. The wasp was not successful in 1993. The adults require warm night temperatures, 60°F minimum, to reproduce. Due to our cool, rainy weather greenhouse temperatures fell below that critical temperature for most of the growing season. The combination of cool night temperatures and the lack of staff to perform adequate monitoring led to a serious whitefly problem by late summer. We used several insecticidal sprays to bring the populations down, rotating between Orthene, Sunspray, Safer's Soap, and Mavrik. By fall the pests had been reduced to acceptable levels. The temperatures were warmer and the wasp was performing better.

Fungus gnats at the repository have always been a problem. In the spring of 1993 some new *Vaccinium* plants were moved from the greenhouse to the screenhouse and several of them died due to fungus gnat infestation. For the rest of the growing season the pest quarantine area was utilized to eliminate pests from the plants that had been grown in the greenhouses before they were placed in the screenhouses. This procedure worked very well, we had no serious fungus gnat or whitefly problems in the screenhouses after this step was taken. We began weekly drenches of the greenhouse plants using 'Gnatrol', ABBOTT, a biological larvicide containing *Bacillus thuringiensis* and 'Exhibit', CIBA-GEIGY, a commercial product containing entomophagous (insect-eating) nematodes. Orthene drenches were sometimes used in place of biological agents for plants being moved out to the screenhouses.

The screenhouse plants were drenched with the biological control agents biweekly.

Spider Mites are another one of our perennial pests here at the repository. We decided to give up on the predatory mites as they did not seem to be controlling the spider mites in the greenhouses and we were short staffed so could not do the amount of monitoring required. We sprayed as needed using a 1:1 mixture of Safer's Soap and Sunspray rotating with Avid, a miticide. Due to the cool, wet summer, spider mites populations were not as high in 1993 as they might have been.

In the *Rubus* screenhouses and in the greenhouses, the plants were misted one to three times each day which did keep the populations low as the spider mites cannot reproduce as well under conditions of high humidity. We may not be able to maintain an adequate misting program in 1994 due to lack of staff. The *Fragaria* and *Ribes* collections were not misted due to their susceptibility to powdery mildew. The *Mentha* collection is sheared monthly which kept the spider mite population under control for the summer and was sprayed with Avid in the fall along with the other susceptible genera to reduce the overwintering spider mite population.

Due to the cool, wet weather conditions of 1993, powdery mildew was a problem in the *Fragaria*, *Mentha*, *Ribes* and the rabbiteye blueberries in the screenhouses. The fans were kept running to improve air circulation and fungicides were applied on the worst cases. Sulfur was not used as phytotoxicity can occur when sulfur and Sunspray are applied to the same plant and in the covered screenhouses the sulfur residue remains on the screenhouse plants for a long time and can get on skin and clothes and cause irritation.

Root weevil larva was controlled using an Orthene drench in 1993 instead of the nematodes which we usually apply in the early fall. The nematodes require a soil temperature of at least 55°F and high soil moisture. The drenching could not be done when these conditions could still be met, thus Orthene was used.

Thrips have not been a problem yet. We are maintaining pots of petunia, verbena and gloxinia for monitoring thrips and tomato spotted wilt virus, we have found none yet. The verbena and petunia plants have also been useful in whitefly monitoring, the whitefly are very attracted to them and they are both covered with glandular hairs which tend to trap the adult whitefly and fungus gnats. The verbena seems to be stickier than the petunia as it always has more insects stuck to it.

During the winter of 1992/1993 we tried a weed prevention method in the potted woody plants in the screenhouses and tubehouses. Approximately one inch of sawdust was applied to the top surface of the pot after weeding to see if we could prevent weed seed germination in the spring. Our major screenhouse weeds are Little western bittercress, *Cardamine oligosperma*, Willow-weed, *Epilobium spp.* and *Oxalis spp.* The bittercress and willow-weed are annuals and serve as alternate hosts for aphids and whitefly, respectively. The oxalis is a rhizomatous perennial and is capable of taking over a potted herbaceous plant such as a strawberry.

The mulch was successful in preventing willow weed and bittercress in the potted plants until later in the summer when the weeds on the screenhouse floors and outside in the tubehouse area went to seed. Once this seed landed on top of the sawdust it germinated and grew readily so the key to weed control in the pots is to keep the surrounding areas weed-free. This is very difficult in the tubehouse area as they are not enclosed and weed seed drifts in from all over. The mulch did not suppress oxalis due to it's rhizomatous nature it is very difficult to remove from a potted plant even when repotting as it entwines its rhizomes in the plant roots.

We also had a weed problem in the fall in the potted plants out in the shade tube area. One day I noticed some digging had been occurring in the pots. I thought it was someone else's weed pulling activities and forgot about it. A few days later hundreds of pea seedlings began germinating in the pots! The squirrels had gone out to the fields, collected pea seed and tried to store them in our potted trees!

Field Collections

Joe Snead and Ray Gekosky

When the *Vaccinium* and *Ribes* were moved out the screenhouses the field plantings became full. These plantings will be enlarged in 1994. The *Rubus* cultivar field planting was removed.

We have planted a new *Rubus* species field at the north farm. This new planting is being done in cooperation with Dr. Chad Finn of the USDA ARS Northwest Small Fruit Research Center. Seedlings were started from the seed collection that Dr. Maxine Thompson brought back from China. These seedlings will be evaluated for performance and novel characteristics.

In 1993 evaluation data was collected for *Fragaria*, *Rubus*, and *Vaccinium* field collections. Disease scores were taken in all three crops. A new incidence of *Botrytis* on *Vaccinium* was noted. Bloom data was taken in the *Fragaria* and *Vaccinium* fields. Crop loss from birds and disease prevented fruit data from being obtained.

We had the pear orchard cut back (topped) to 12 feet by a special machine. This will enable us to keep the trees within workable bounds. The orchard is looking to be in great shape.

RESEARCH EFFORT

Tissue Culture

Barbara Reed and Carolyn Paynter

The in vitro collection will change considerably in the next few months to conform to recent decisions of the Technical Advisory Committee. Some collections will no longer be kept in vitro (*Corylus*, most *Humulus*) while others will have reduced representation (*Ribes*, *Mentha*, *Rubus*) and others may change in composition (*Fragaria*, *Pyrus*, *Vaccinium*).

Bacterial contaminants from mint cultures were characterized and most were identified to the genus level. Agrobacteria, Xanthomonads, Pseudomonads and several lesser known genera were represented. Minimal bactericidal concentrations of four antibiotics were determined for the contaminants. Phytotoxicity of the antibiotics was also evaluated and treatments were developed for many of the infected cultures. Dr. Buckley is now working at Microplant Nurseries in Gervais. Ms. Piyarak Tanprassert will be conducting bacteriological studies with contaminated *Fragaria* cultures as part of her M.S. work.

Graduate student Xiaoling Yu completed her Ph.D. in September. She improved media formulations for the hazelnut collection and developed micropropagation systems for two non-suckering hazelnut-rootstock selections and the newly-released nut cultivar 'Willamette'. She also developed methods for regeneration of plants from leaf discs and stem segments. She is currently employed as a Research Assistant and is in charge of propagation, inventory and student supervision as well as cryopreservation research.

Graduate student Dennis Yeo completed his M.S. in August and is now in Japan. He developed micropropagation systems for pear rootstocks for his M.S. thesis. He found that auxin (either NAA or IBA) at 0.5 μ M significantly improves multiplication of the shoot cultures compared to higher or lower concentrations.

Graduate student Mohan Kumar will begin a M.S. research project on detection of variants of tissue cultured *Fragaria*.

Drs. Ruchira Pandey and Neelam Sharma visited us in April and May. They are scientists with the National Bureau of Plant Genetic Resources in New Delhi, working with in vitro and cryopreservation techniques.

Cryopreservation

Barbara Reed

Work is continuing on cryopreservation of *Ribes* species and cultivars. Four cryopreservation methods are being tested on several genotypes to determine the most useful technique for a range of genotypes.

Dr. M. N. Normah spent a three month sabbatical leave from Universiti Kebangsaan Malaysia at the Repository. She works with cryopreservation of recalcitrant tropical seeds and tissue culture of tropical species. During her stay we studied cryopreservation of hazelnut seeds and isolated embryonic axes. Final parts of the work are being completed at this time with the assistance of Dr. Yu.

Graduate student Mr. Jie Luo will begin a M.S. project on cryopreservation.

Mr. Yongjian Chang, Assistant Professor at Changli Institute of Pomology, Hebei Academy of Agricultural and Forestry Science will be at the Repository as a visiting scientist for one year starting this summer. His work with tissue culture and cryopreservation of apple cultivars is complementary to the work we are doing with pears.

Mint Collection

Henrietta Chambers

This year A chromosome survey of the NCGR mint was submitted to TAXON Journal of the International Association of Plant Taxonomists. Most of the data from the study of herbarium collections of native *Mentha* from Australia and New Zealand into a working database. All remaining data will be entered during the next several months. This database will provide a "packet" of information including exact localities and ecology on recent collections. We now have three of the seven native taxa of *Mentha* from Australia and New Zealand and are anxious to obtain the rest. We will designate a core mint collection, and repot the greenhouse plants.

Ribes: Molecular Biology

Wes Messinger

Knowledge of evolutionary relationships and genetic distances can be invaluable to the plant breeder. This knowledge is required for rigorous investigation of many basic biological questions.

I have been pursuing molecular systematic research in the genus *Ribes*. My results will improve the subgeneric classification of the genus (crosses within *Ribes* subgenera are much more likely to succeed) and provide an evolutionary framework in which to pose interesting questions about *Ribes* biology.

Infrageneric classification, i.e., sectional differences, in *Ribes* has previously relied on only a few morphological markers, "such as spines, glands, or inflorescence morphology. Chemical and anatomical studies show the genus to be remarkably uniform, and do not provide useful data for systematics. I surveyed 32 species, representing all sections for restriction site variation in two regions of chloroplast DNA. The data are remarkably consistent, and indicate that red currants. European alpine currants, golden currants, the gooseberries and California gooseberries are each distinct and monophyletic. Unexpectedly, spiny currants and true gooseberries are united, suggesting either a sister group relationship or the possibility that one of these groups arose by an ancient hybridization event. Spines appear to have arisen repeatedly in the genus. The black currant species examined exhibit surprisingly high divergence, and are not monophyletic in the analysis.

Rubus Germination

Derek Peacock

A major effort is underway to germinate *Rubus* species collected by Dr. Maxine Thompson, Dr. Jim Ballington, and others, from China, Ecuador, and other foreign countries. Approximately 70 seedlots have undergone various pretreatments to encourage germination. Dr. Chad Finn will collaborate with us on the evaluation of these exotic species.

While working with various *Rubus* pregermination treatments, we have observed mixed responses to sodium hypochlorite (NaOCl) as a seed scarifying agent. For *R. parviflorus* Nutt., scarification with NaOCl resulted in 34% germination. Fewer than 1% of the seedlings showed any negative

effects after exposure to 2.6% NaOCl for 24 hours. But in *R. ursinus* Cham. & Schldl., *R. multibracteatus* A. Leveille & Vaniot, *R. swinhoei* Hance, and *R. setchuenensis* Bureau & Franchet, the percentage of injury observed ranged from 40% to 100%. In these cases, although embryonic tissue did not appear necrotic, the radicle and plumule failed to elongate after emergence. The epicotyl or primary leaves did not develop, and the radicle failed to form root hair. The cotyledons, apparently unaffected, opened and were a healthy green. NaOCl did not seem to kill the embryo, but deterred development of the embryonic axis.

Future research towards the development of a new germination protocol for *Rubus* includes additional evaluation of the effects of sodium hypochlorite, as well as other germination pretreatments including sulfuric acid, potassium nitrate, and various macerating enzymes.

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ABSTRACTS

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