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Can You Afford Not to be a DNA-Informed Breeder?

By Cameron Peace, MAB Pipeline Team Leader

Marker-assisted breeding (MAB), in any and all of its myriad forms, is the future of rosaceous crop breeding. That forecast was obvious from the recent FruitBreedomics first annual meeting in Prague, Czech Republic.

The air outside might have been frigid, but communication was warm and topics were hot as 90 interested invited breeders and project participants gathered to discuss progress and plans at the Czech University of Life Sciences in Prague on 6-10 Feb 2012. The FruitBreedomics project (fruitbreedomics.com) is now in the twelfth month of a 4.5-year effort that closely parallels RosBREED. The project is equivalent in its goal ("bridging the gap between genomics and fruit breeding"), scope (€10M including in-kind support), approach (e.g. Pedigree-Based Analysis is integral), and even has a breeder as its Coordinator (Francois Laurens, apple breeder at INRA, Angers, France) who is committed to translating the promise of genomics and molecular genetics breakthroughs into a revolution in new cultivar development for rosaceous crops. I was invited to attend the meeting, as RosBREED's emissary to this sister initiative and part of the Advisory Board, to strengthen our synergies and expand the potential impact of both projects.

Drs. Marco Bink and Eric van de Weg share Pedigree-Based Analysis expertise with European breeders at the first annual Fruit Breedomics meeting in Prague, 6-10 Feb

European fruit breeders were the stars of the "Stakeholder Platform Day" held on Tue 7 Feb! Did you know that perhaps a third of apple breeders on the other side of the Atlantic are already using DNA information routinely in their breeding decisions? That result from a breeder survey conducted during 2011 with 31 respondents surprised even the project leaders. Current applications of genetic markers in Europe run the whole gamut, from identifying exotic sources of novel attributes, through understanding genetic relationships in breeding germplasm, choosing optimal cross combinations, confirming or identifying parentage, preselection of superior seedlings, variety identification, and for IP protection. I think I also detected some genetic marker evaluation for performance potential of advanced selections and new releases. Several breeders gave inspiring presentations on the objectives and scope of their programs, and their MAB experiences and expectations. The mood was positive and several breeders explained how they are already using markers to support breeding decisions. Ramping up of MAB was a common theme, especially if FruitBreedomics delivers.

Costs and benefits of routine genetic screening Are Rosaceae crop breeders willing to pay the cost of DNA-testing their material? Both FruitBreedomics and RosBREED are giving attention to enabling routine genetic screening for Rosaceae breeders at large. Genetic screening involves the four steps of tissue sampling, DNA extraction, genotyping, and timely provision of results to the breeder. These services are each associated with a cost. Recent investigations by our Genotyping Team of the costs of genetic screening services provided by most commercial companies indicates that for each individual screened with just a few markers, a breeder will rarely get change from $10 per for the full service. But large orders drop the price, my own experiences attest that services without profit are a small fraction of this cost, and technological advances will continue to drive down prices.

To be conducted routinely, such costs obviously need to be less than the benefit gained by a breeder. So what are the benefits? Here are four:

1) Staying ahead of the competition
2) Knowledge of efficient crosses
3) Knowledge of inferior seedlings
4) Knowledge of genetic potential and uniqueness of advanced selections

Staying ahead of the competition An interesting discussion on this topic ensued at the Prague meeting. Consider this: Breeding for short-generation field and row crops in the private sector now routinely involves MAB. Because MAB is now the norm, breeders who aren't DNA-informed will quickly fall behind their competition. In this scenario, breeders will be willing to genetically screen their material for predictive markers even if it represents a cost to their program because of the benefits of more rapidly releasing more superior new cultivars than without MAB. For breeders of long-generation rosaceous crops, the current average "competition" is still conducting conventional breeding rather than MAB, and the pay-offs for MAB can seem many years away. However, judging from the proportion of European breeders that are getting on board, some U.S. breeders may soon be left behind. And current breeding for shorter-generation crops like strawberry seems held back not by cost concerns but by a lack of predictive markers.

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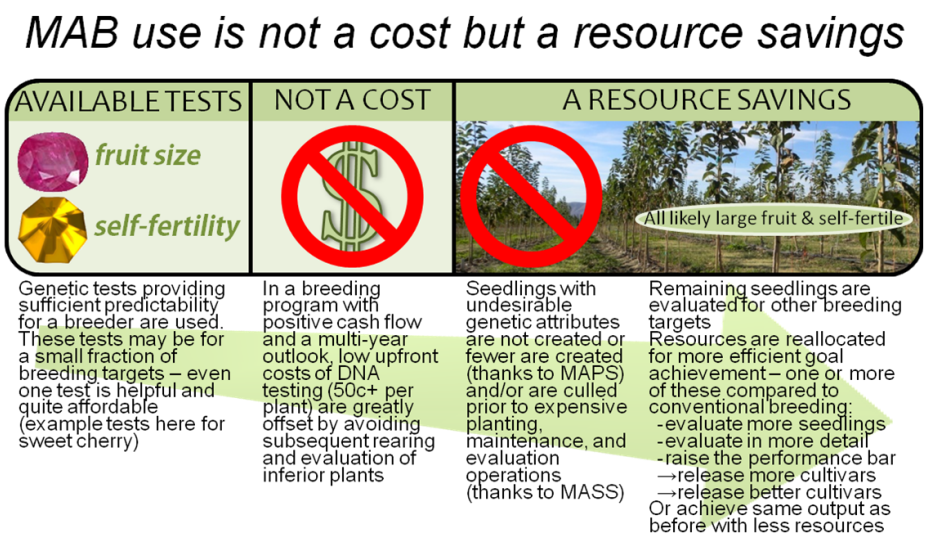
Knowledge of efficient crosses Genetically screening the parental genepool is a wise investment. As few individuals are involved, the cost is low. Information gained includes identifying the presence of favorable alleles with excellent combining potential, as well as defining relatedness among possible parents to help avoid unwanted inbreeding, maximize crossing among unrelated individuals for transgressive segregation via complementarity of favorable alleles, and avoid incompatible crosses. The value of this DNA information is multiplied because screened parents are considered and used over and over. Furthermore, where DNA information identifies more efficient cross combinations than those indicated by phenotype, pedigree records, or past experience, the value is greatly amplified because it affects many individuals of the next generation. For example, screening 50 parents with a single genetic test to identify several that are homozygous for a favorable major-effect allele and then crossing among them is much more cost efficient than crossing parents of unknown zygosity, then genetically screening hundreds to thousands of seedlings to cull inferior genotypes.

Knowledge of inferior seedlings Marker-assisted seedling selection (MASS) is one extreme of MAB for cost considerations, yet also affordable for any breeder with even a single genetic test of interest. Information gained on each individual is used once and the seedling then either discarded or kept. For MASS to be cost-effective, the cost of genetic screening must be below the average cost of raising and evaluating an inferior seedling. For both Washington State University's apple and sweet cherry breeding programs, this latter cost is much more than $10, and thus MASS is cost-effective even with a commercial service provider. (However, my own Pacific Northwest Tree Fruit Genotyping Lab in Pullman, which routinely screens thousands of seedlings annually for these two breeding programs, conducts the service without profit for well under 10% of the cost of phenotypic selection*.) If you do the sums for conventional breeding in your own program, you'll find that high-throughput genetic screening of thousands of seedlings is worthwhile even with just a single predictive marker, and even if you had to go through the most expensive quartile of commercial service providers. My breeding-assistance program has developed a spreadsheet tool that makes doing these sums much easier, which I'm happy to share; RosBREED is converting this spreadsheet into software for eventual release as one of the eight modules of the Breeding Information Management System (see pages 5 and 6 of this issue). Use of this tool will change your perspective: MASS is a resource *savings* strategy, not a cost.



** Sorry, this service is not available to the rest of you, only the advice from our practical experiences on the front line of MAB!*

Knowledge of genetic potential and uniqueness of advanced selections Genetic screening your advanced selections brings the impact of DNA technologies to your program *now* rather than a generation from now. Advanced selections are limited in number and therefore genetic screening costs are relatively small. Yet the benefits can be enormous. First, newly available or previously unused performance-predictive markers can be used to cull inferior selections from advancing any further in the program. All Rosaceae breeders can take advantage of this opportunity now and increasingly in the future – because there are already some available jewels for most crops, RosBREED is currently polishing many more, and into the foreseeable future researchers will continue to fill the public treasury. Second, predictive markers can be used to describe but not cull selections. Most genetic tests currently available are for attributes that are not superior or inferior in all production situations – for example, genetic tests for level of skin blush of apple, or for non-melting vs. non-softening flesh of peach. Describing advanced selections with such markers can help direct a new cultivar release to its optimal production environment, guide management decisions, or at least help inform growers of what to expect. For what it's worth, DNA-verified parentage is becoming the norm in Rosaceae crops for which cultivar recognition in the industry is important, for all but the shortest generation crops. Cherry breeders cannot afford to release cultivars without DNA information of *S*-genotypes. DNA information is already finding its way into nursery descriptions of cultivars and may expand in the future as we refine the predictive power of genetic tests. In some cases, genetic tests will reveal information of genetic flaws, perhaps unwanted – but perhaps it's better to know that as early as possible and manage the release of such information than to leave it up to someone else to soon find out.

So, can you afford to become a DNA-informed breeder? Yes!
Can you afford *not to*?