Comparing the influences of traditional seed exchange and modern crop improvement on population structuring and genetic diversity

by Brook Brouwer and Adam Peterson

Main Questions:
- How do traditional seed exchange networks influence crop genetic diversity and population structuring?
- How do these systems compare to conventional breeding approaches?

Definitions:
- Landrace: A diverse population adapted to a specific location through natural and farmer mediated selection
- Modern varieties: Uniform varieties intensively bred through modern breeding techniques
- Seed system: means by which farmers obtain seed for planting
- Traditional seed exchange: A system where farmers regularly replant their own landraces, adapting them to natural conditions and to their own needs, while regularly exchanging seed with other farmers

Cases Involving Traditional Seed Exchange

Case #1: Oaxacan Maize (Pressoir and Berthaud, 2003)

-Looked at maize in its center of origin
-Investigated 31 populations within 6 villages using microsatellite and chloroplast markers
-Found that high levels of seed exchange negated any distance effects on isolation:
    -Among populations: Fst=0.011
    -Among villages: Fst=0.003
    -Ratio of pollen to seed flow: r=0.55
-Odd case of Wahlund effect: "locus dependent substructure". Flowering time resulted in elevated levels of homozygosity due to temporal effects on mating (Fis=0.13)
-Generally, ***little population structuring over distance***. However, distance effects on Fst have been found in other studies (Gauthier et al, 2002; Sanou et al, 1996)

Gauthier P, Gouesnard B, Dallard J, Redaelli R, Rebourg C, Charcosset A et al (2002). RFLP diversity and relationships among traditional European maize populations. Theor Appl Genet 105: 91–99.

Pressoir, G., and J. Berthaud. 2003. Patterns of population structure in maize landraces from the Central Valleys of Oaxaca in Mexico. Heredity 92(2): 88–94.

Sanou J, Gouesnard B, Charrier A (1996). Isozyme variability in West African maize cultivars (Zea mays L.). Maydica 42: 1–11.

Case #2: Bolivian Quinoa (Del Castillo et al, 2007)

- Looked at two populations each in 4 ecoregions for total of 8 populations, including weedy and cultivated material
- Ran RAPD markers and analyzed via AMOVA
- 27% variation among ecoregions, 25.2% among populations within ecoregions, and 48% within population variation.
- Mean Fst=0.287, ***so significant structuring***
- No significant grouping differences between weedy and cultivated material - they grouped by location. Author refers to weedy and cultivated *C. quinoa* as a 'monophyletic co-evolving unit'.

Del Castillo, C., T. Winkel, G. Mahy, and J.P. Bizoux. 2007. Genetic structure of quinoa (Chenopodium quinoa Willd.) from the Bolivian altiplano as revealed by RAPD markers. Genetic Resources and Crop Evolution 54(4): 897–905.

Case #3 Barley (Jensen et al, 2012)

- Combined farmer interviews of seed saving practices with genetic analysis using SSR markers
- Samples 3-4 seeds per farmer, 2-4 farmers per village, and 4 villages per commune
- Variety 'Beldi' loosely defined - can be thought of as a complex
- Low, but significant Fst between communes (Fst=0.031).
- More seed exchange occurring than reported by farmers

Jensen, Helen R., L. Belqadi, P. De Santis, M. Sadiki, D. I. Jarvis, D. J. Schoen. A case study of seed exchange networks and gene flow for barley (Hordeum vulgare subsp. vulgare) in Morocco. Genetic Resources and Crop Evolution, no. 3 (2012): 1-20.

Case #4: Advanced Cycle Breeding - Minnesota Barley Program (Condón et al, 2008)
- Looked at effects of breeding on genetic diversity
- Analyzed with 70 SSR markers and one gene specific marker
- Ran PCA analysis, saw gap between ancestral cultivars and modern elite cultivars, along with genetic narrowing over time
- Saw reduction in alleles per loci over time (from 5.89 alleles/loci to 2.34 alleles/loci)
- "Locus specific changes" - certain alleles were fixed for their loci and were under high selection in breeding program for desirable traits (however, this may be tied to drift)
- 7 of 34 parental lines contributes 71.4% of variation in the barley programs elite lines

Condón, F., C. Gustus, D.C. Rasmusson, and K.P. Smith. 2008. Effect of Advanced Cycle Breeding on Genetic Diversity in Barley Breeding Germplasm. Crop Science 48(3): 1027.

Interesting Concluding Thoughts:

-Seed exchanges provide an interesting island migration models: farmers mediate migration through seed exchange

-Diversity and structure are variable depending on loci. For instance, population structuring exists on the locus-level with Oaxacan maize. Alleles per locus vary in Minnesota depending on if the loci is responsible for traits under selection.

-Social factors key to the development, exchange, and structuring of crop genetic diversity.