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ORIGINAL ARTICLE

Optimization of genetic gain and diversity in seed orchard crops considering variation in seed germination

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Abstract
Balancing genetic gain and diversity in seed orchard crops is of a major regeneration importance. Here we extend our earlier work on the development of an optimization protocol that maximizes crops' genetic gain at any predefined diversity level, considering parental reproductive output, co-ancestry, and inbreeding, by incorporating variation in seed germination as an input. Variation in seed germination capacity substantially affected seedlots' genetic diversity by either under- or overestimating their effective population size; however, genetic gains were robust and their differences were negligible. The contrasting results of gain and diversity support the inclusion of the germination capacity, when available, in the optimization protocol.

Keywords: *Seed orchard, germination capacity, optimization, genetic gain, genetic diversity.*

Introduction

The genetic quality of seed orchard crops is determined by the genetic gain and diversity they harbor. The former depends on orchards' parental breeding values and genetic efficiency (parental reproductive success, mating pattern, and the level of pollen contamination) while the latter is mainly affected by the size of the parental population, balance in reproductive success and kinship among its members, and inbreeding. The genetic quality plays a key role in seed crops' utilization as higher genetic gain is expected to result in improved forests while genetic diversity maintains adaptability and secure responses to unpredictable environmental contingencies such as climate change or biotic and abiotic stresses (Stoehr et al., 2004). Genetic diversity can be approximated by effective population size (Wright, 1931), effective number of parents, or – in the presence of relatedness among individuals as in the case of advanced generations seed orchards – by status number (Lindgren et al., 1996). In some forestry jurisdictions; seedlots' genetic diversity is regulated for its acceptance for reforestation. For instance, effective status number of 10 is set as the threshold for use on Crown land in British Columbia (Stoehr et al., 2004; Woods, 2005) as this value is generally considered adequate for capturing the majority (95%) of genetic diversity in a population (Nei, 1973; Yanchuk, 2001).

Estimating the genetic quality in orchard crops is commonly done through a visual assessment of parental fecundity (reproductive investment) (Woods, 2005). Although parental fecundity was found to substantially vary in most studies (Askew, 1988; Burczyk & Chalupka, 1997; El-Kassaby & Askew, 1991; El-Kassaby & Reynolds, 1990; Kang, 2000), its relationship with the actual reproductive success was not known and the assumption of congruence between these two variables required evaluation (see El-Kassaby & Cook, 1994; Funda et al., 2011). The most accurate parental fecundity estimates can be obtained using either partial (El-Kassaby et al., 2011; Funda et al., 2008; Moriguchi et al., 2004; Slavov et al., 2005) or full

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