Heterotic effects and genetic distance for the prediction of agronomic performance in crossing divergent alfalfa populations

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Abstract: Alfalfa is an autotetraploid, allogamous and self-incompatible plant species, where each cultivar is a heterogeneous population with heterozygous individuals (genotypes). The common breeding program approach in alfalfa includes recurrent phenotypic selection with or without progeny testing, to accumulate desirable alleles at high frequency into a population. Heterosis, the superior performance of hybrids relative to parents, has been well documented in a number of cases in alfalfa. This research considers the concept of molecular and genetic basis of heterosis as well as possibilities of using genetic distance in prediction of heterotic effects in alfalfa. Five divergent parental alfalfa (*M. sativa* ssp. *sativa*) populations were crossed in a diallel mating design. For each pairwise cross, five plants were chosen at random from each of the two populations (~100 florets per plant) to obtain F_1 progeny. Parental populations were analyzed by RAPD markers which were used to calculate their genetic distance. Genetic distance estimation was used as a method for evaluating progeny similarities within a population, for choosing adequate parents for crossing to maximize heterotic effects. The highest HPH values were identified in hybrids from crosses between parent populations that were genetically homogeneous (Pecy and RSI 20 namely). Hybrids created by crossing divergent alfalfa populations expressed HPH for DM yield, plant height, internode number and length, stem diameter and leaf to stem ratio in DM yield. The highest magnitude of HPH for DM yield, plant height and leaf to stem ratio in DM yield was recorded in cross between parental populations Pecy (France) and RSI 20 (Spain). Population RSI 20 is characterized by large, high-yielding plants with rapid regrowth and high leaf to stem ratio. On the other hand, population Pecy has high leaf to stem ratio and short internodes. Heterosis could be a consequence of combining complementary genes for these traits, producing vigorous leaf-abundant hybrid plants that yield more. Heterosis for yield was also recorded in hybrids from crosses of populations GYG (Iran) and RSI 20 (Spain), and both were selected for production in irrigation regime. Semi-hybrid breeding strategy is based on crossing populations to avoid the need for inbred lines, which is intended to capture partially heterotic effects. Selected parental populations should belong to the same dormancy group and be similarly tolerant to abiotic and biotic stress, in order to reduce genetic load. Molecular markers should be applied to assess genetic structure of a population (homogeneity), and calculate genetic distance. Heterosis in autotetraploid plants mostly depends on the progressive approach to the maximum of gene interactions. Considering the fact that alfalfa is an autotetraploid species and that breeders work on populations or population hybrids, it is expected that the effects of heterosis will sustain throughout the following 3 to 4 generations of multiplying semi-hybrid seed, which remains to be experimentally confirmed.

Key words: alfalfa, heterosis, genetic distance, population hybrids