

Genotype mixtures as a tool to develop sustainable agriculture? Elucidating the mechanisms that drive genotypic interactions in crops

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Introducing genetic diversity within fields has been proposed as a way to take better advantage of ecological processes and develop more sustainable agrosystems with reduced chemical inputs. Indeed, beneficial effects of mixing varieties have been reported in the literature. However, lower performance of mixtures has also been documented. Negative interactions among genotypes may result from (i) kin selection that operates at the group level whenever interacting individuals are related, (ii) indirect genetic effects where the phenotype of an individual depends on the genes of its social partners. These mechanisms remain poorly explored in plants. In agriculture, it is well established that the phenotype of a plant is affected by the phenotype of its conspecific neighbors. Thus, social interactions are the rule. Moreover, human practices have decreased within-field genetic diversity, leading to high relatedness among plants. Because agriculture has been maximizing group performance and human selection has occurred among groups of related individuals, human selection may have acted as kin selection in crops. Kin selection may explain poorer performance of varietal mixtures compared to monocultures, whenever individuals express phenotypic plasticity in response to their genetic relatedness to neighbors and reduce competition with their kin. This can happen with kin discrimination whereby helping behavior is preferentially directed towards kin. Using durum wheat as a model species, we conducted an experiment where plants were grown in groups of five with different levels of genetic relatedness, to test whether kin discrimination and IGEs may explain poorer performance of genotype mixtures. Our results do not support the occurrence of kin discrimination and reduced competition towards kin. Instead, group fitness was mostly driven by competitive interactions between genotypes, as evidenced by a negative correlation between direct genetic effects and indirect genetic effects. Overall, our study calls for extending evolutionary approaches to address pressing issues in agriculture.