Comparative Analysis of Wild Annual and Herbaceous Perennial *Astragalus* (Fabaceae)

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Abstract

Contemporary agriculture contributes to many ecological problems such as biodiversity loss and soil erosion, due in large part to the cropping system used. Grain crops (corn, wheat, etc.) are grown in annual monocultures, vast areas planted with one species that are plowed and replanted annually. Although they have been instrumental to the construction of society as we know it, annual monocultures are not found in nature. Natural tallgrass prairies are perennial polycultures, mixtures of many different species that regrow every year. Some benefits of this system include increased biodiversity, ecosystem resilience, carbon sequestration, and reduced soil erosion. As such, perennial polycultures have been proposed as an auspicious solution to many ecological issues caused by contemporary agriculture. However, herbaceous perennial crops have rarely been domesticated. This begs the question, can herbaceous perennials be artificially selected for increased reproductive yield without trade-offs in their vegetative structures "annualizing" them? This study examines differences between perennial and annual congeners in the monophyletic genus *Astragalus*. Two perennial species (*Astragalus canadensis* and *A. crassicarpus*) and two annual species (*A. lindheimeri* and *A. nuttallianus*) were selected for examination based on their natural ranges in North American temperate regions and previous use as food sources. We hypothesized little to no difference between perennials and annuals in (1) germination rates; (2) seedling growth rates; (3) seedling biomass allocation (root:shoot mass ratio) between the two; and (4), that there would be no correlation between reproductive and vegetative structures evident in wild-collected mature plants. Two different datasets were generated to test these hypotheses, one using live plants (hypotheses 1-3) and one using herbarium specimens (hypothesis 4). Results were analyzed using generalized linear mixed-effects models, factorial and one-way analyses of variance, and Spearman's correlation matrices in R. Germination trials were conducted with and without cold stratification; trials found only minor differences between the life strategies but significant differences between stratified and non-stratified replicates. Germinated seeds were transplanted and their growth rates measured over three weeks; perennials were nearly identical to annuals. Next, seedlings were harvested, dried, and the separate masses of their root and shoot systems measured showing only marginal differences between the two, though perennials tended to have larger roots. Finally, herbarium measurements were taken of five reproductive and four vegetative traits. Correlation matrices of the traits showed that in annuals, nearly all reproductive and vegetative structures are positively correlated. *A. canadensis* mirrored this structure while *A. crassicarpus* had many more negative correlations. Overall, this study found only statistically minor differences in germination, growth rate, and biomass allocation of *Astragalus* perennials and annuals. Reproductive and vegetative structures are definitely related in these species but further study is needed to confirm the structure of the correlations in herbaceous perennials. Of the species studied, *A. canadensis* appears the most promising herbaceous perennials candidate for domestication. Perennial grain crops are certainly not out of reach - they are, perhaps, the future of agriculture and it's very possible that future contains herbaceous perennial *Astragalus* species.