

Heredity of Taproot Phenotype in *Taraxacum kok-saghyz*

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ABSTRACT

A taproot phenotype, which consists of one large singular root, is preferred over a multiple root phenotype to maximize harvest efficiency of the new Ohio rubber crop *Taraxacum kok-saghyz* (TK). In this study, rare field-grown taproot plants were interbred and the incidence of taprooted plants quantified in their F1 progeny and compared to controls. Transplants were required to increase the pressure on plants to form multiple roots and allow detection of F1 plants genetically programmed to be a taproot. Development of a tap-rooted TK crop should reduce loss of rubber containing roots at harvest, increasing yield per acre.

INTRODUCTION

Taraxacum kok-saghyz (TK) is under development in Ohio as a domestic natural rubber (NR) crop, to protect U.S. supplies, stabilize global prices, and supplement the tropically-produced NR from the rubber tree. TK plants have several natural root phenotypes or architectures: a taproot with no branching (Fig. 1A), a multiple root system where 2, 3, 4 or more roots develop from the crown (Fig. 1B), and also a taproot phenotype that develops branched roots toward the middle or tip (Fig. 2). Substantial losses in rubber yield occur during harvest as small roots are broken off and lost. This occurs in all harvest methods tested, including hand-digging plants from loose soil in raised beds, manual harvests using shovels in the field, and larger machine-driven field harvests. Rubber concentration is independent of root size [1] but its relationship to root architecture has not yet been investigated.



Figure 1. TK plants displaying A) taproot and B) multi-root phenotype.



Figure 2. TK plants displaying taproots with distal branching.

MATERIALS AND METHODS

Original Taproot Collection

- During the 2014 TK field root harvest, 87 tap-rooted plants (no branches) were selected.
- These were repotted, grown in the greenhouse, and were interbred across the population at flowering to produce F1 seed.

Direct Seeding F1 Seed

- A portion of the F1 seed and a complimentary control seed lot were direct seeded into treepots in the greenhouse, with one seed/pot, and grown for six months (Fig. 3A).
- Plants were harvested, root fresh weight was measured, root phenotype recorded, and root rubber concentration was quantified using Near Infrared Spectroscopy (NIRS). [2]

Transplanting F1 Seed

- F1 and control seed also were planted into transplant trays, in order to induce multiple roots, and grown for 3 months in a greenhouse before being transplanted into treepots and grown in the greenhouse for 3 additional months.
- The plants were removed from the pots, root architecture was recorded, and the plants were repotted and grouped by architecture.
- Plants with the same root architecture were interbred, keeping the controls separate.
- F2 seed is currently being collected (Fig. 3B).



Figure 3. A) F1 direct seeded plants in treepots in the greenhouse. B) F1 transplants flowering and producing F2 seed.

RESULTS

When direct seeded into light soil in the greenhouse, 90% of both the F1 (taproot x taproot) *and* the control plants formed a taproot (Fig 4A). When 3 month old plants were transplanted from trays into tree pots containing the same soil type, 3 months later 74% of the F1 plants had a taproot compared with only 47% of control plants (Fig. 4B). No correlations were found when comparing root fresh weights between F1 and control plants (Fig. 5), but the F1 plants were generally larger than the controls (Fig. 5A). The F1 multiple root plants were the largest (Fig. 5B), but because there was only one multiple root plant in the control group we could not do a direct comparison between the F1 and control multiple root plants. An analysis of variance (ANOVA) found no significant difference in root rubber concentration between taproots and multiple root phenotypes, or between the control and F1 plants.

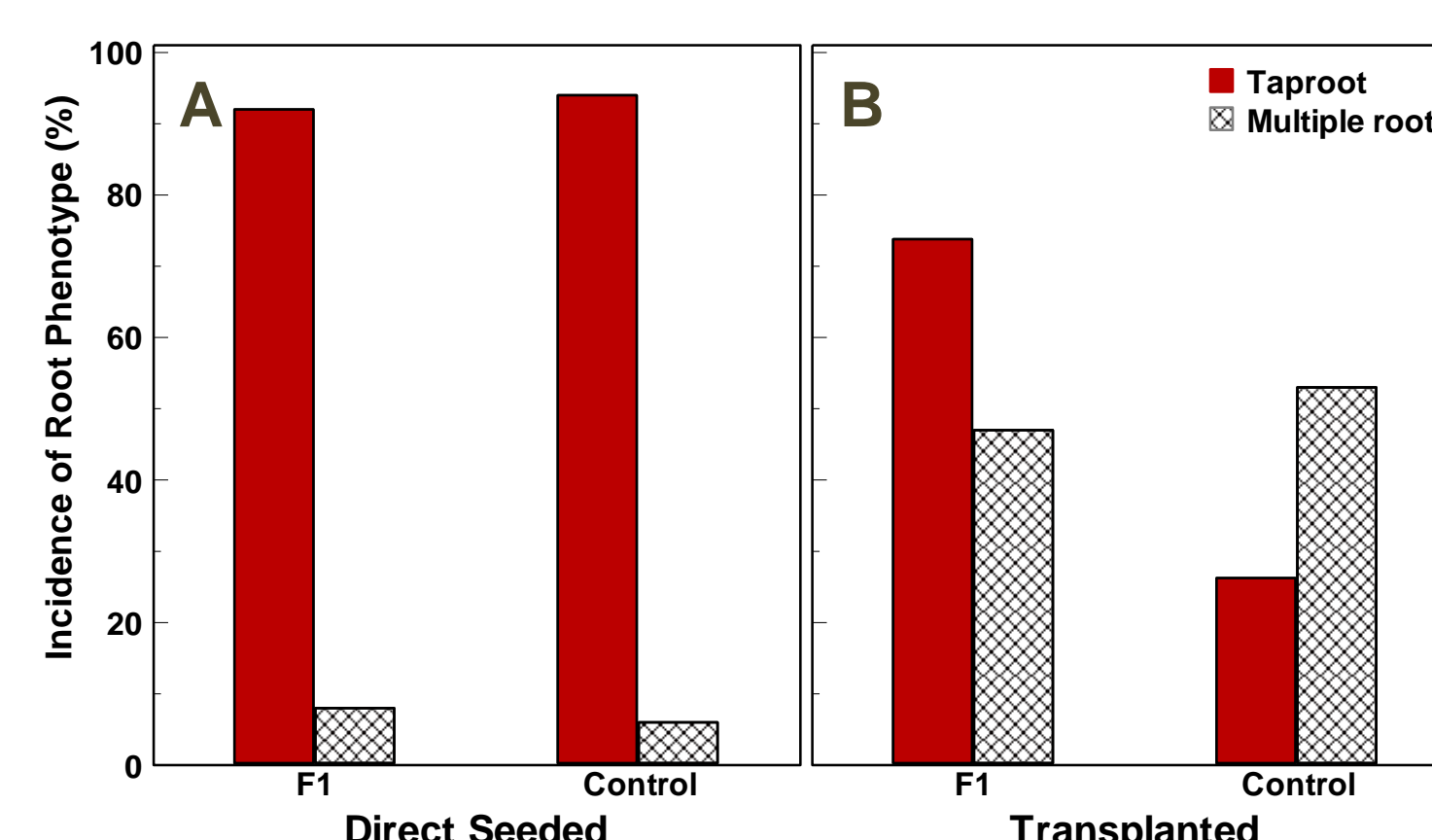


Figure 4. Frequency of taproot and multiple root in F1 and control plants grown from (A) direct seed, and (B) transplants.

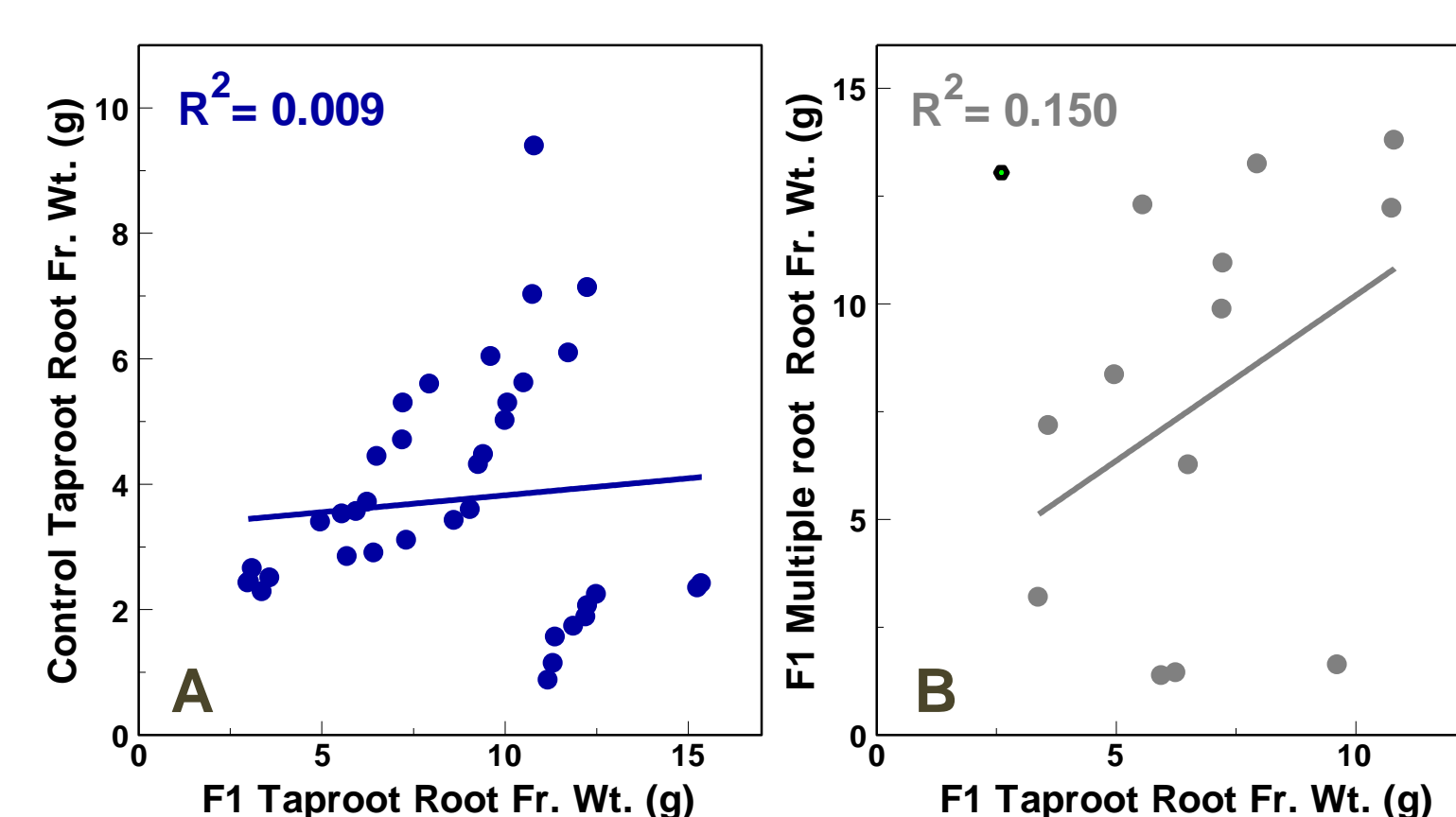


Figure 5. Relationship of root fresh weight (A) between taproots grown from control and F1 seed, and (B) between multiple roots and taproots both grown from F1 seed.

DISCUSSION

Incidence of taproot architecture in mature field-grown plants from the 2014 root harvest was less than 0.001% of all plants harvested. Direct seeding control seed in pots showed that most TK plants will form a taproot under soft soil conditions. This method prevented detection of any improvement of taproot percentage achieved by interbreeding rare field taprooted plants. Transplanting the F1 and control plants increased the pressure on the plants to form multiple roots and this allowed us to detect plants genetically programmed to be a taproot. 25% of plants from the F1 seed retained their taproot phenotype at maturity under conditions designed to induced multiple roots. This 25% incidence, compared to the incidence of their parental taproot in the original population (<0.001%), indicates that genetic heterozygosity for the genes regulating taproot was present in the parental genotypes.

Taproots were, in general, smaller than multiple root systems (Fig. 5), but large taproots do occur especially in planting boxes (Fig. 6). Since rubber concentration was not affected, a taproot TK crop may allow a greater planting density, which would compensate for lower rubber yield per plant. TK plants of mixed root morphologies have been shown to self-thin when planted above 500,000 plants/acre, but that root size does not significantly decrease until over 1,000,000 plants/acre is achieved



Figure 6. Nikita Amstutz holding a prime TK taproot from a planting box.

[3]. Tap-rooted plants are likely to have less self-thinning at comparable densities than multiple root plants. Planting TK closer together also will encourage the plant canopy to fill in more quickly, covering the soil and suppressing weeds.

CONCLUSIONS

Taproot is a heritable, likely multigenic, trait in TK. The taproot incidence in the F2 generation will further elucidate the inheritance of taproot in TK. Development of a tap-rooted TK crop should reduce loss of rubber-containing roots at harvest, increasing yield per acre.

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