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Multi-environment Performance of *Taraxacum kok-saghyz* Clones to Validate Indirect Selection

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ABSTRACT

Reliable selection is essential in successful crop domestication. To test current selection methods in the highly diverse germplasm of emerging natural rubber crop, *Taraxacum kok-saghyz* (TK), clonal plants of individual TK genotypes with known root rubber concentration were generated by root cuttings and planted in three growing environments. Root size and root rubber concentration at harvest were compared within and between genotypes. Mean root rubber concentrations of each genotype were consistent across the different environments but mean root fresh weight was highly variable. Intra-clonal variation for both traits was high, causing overall low (but positive) correlation coefficients of genotype performance among environments. This variation may result from the position of the specific cutting on the original root.

INTRODUCTION

Crop domestication efforts for *Taraxacum kok-saghyz* (TK), a temperate dandelion species that produces high quality natural rubber, are intensifying each year; especially in Ohio where TK acreage is expanding.

Early efforts to domesticate TK are hampered by the extreme genetic variation exhibited by this sexual diploid species. This can clearly be seen in the prime yield traits of root size and root rubber concentration. Multiple rounds of recurrent breeding and selection will be needed to reduce the natural heterozygosity of these multigenic traits. It has also been shown that rubber (a terminal sink) accumulation is very sensitive to physiological and environmental variation[1].

Selection for traits in TK often occurs in a greenhouse environment where conditions are well controlled and soil is light. We do not yet know if heritability of root size and rubber content is sufficient to allow performance in the greenhouse to predict performance in the field.

To address this question we compared performance of clonal TK plants in which genetically identical replicates of a range of genotypes, were grown in three separate environments, namely greenhouse, outdoor planting box, and field.

MATERIALS AND METHODS

→Root cuttings (clones) were taken in January 2016 from twelve different TK genotypes with known root rubber concentration. Clones were placed in vermiculite in the Williams Greenhouse and grown until intact plants were fully regenerated (Fig. 1).

→In May 2016, nine clones per genotype were transplanted in a completely randomized design to each of three environments (Fig. 2); Madison Greenhouses in raised beds, outdoor planting boxes on OARDC main campus, and a field at Fry Farm.

→Greenhouse and planting box plots were watered 2-3 times per week and fertilized once a week with 150 ppm 20-20-20 fertilizer, per our standard methods of plant care in these environments. The field plot was watered only for the first month after transplanting.

→Field plots were covered with straw for three weeks after planting to protect the small cuttings. All plots were weeded by hand biweekly.

→Plants were harvested in November 2016 and plant size parameters measured. Root rubber concentration was quantified using Near Infrared Spectroscopy (NIRS) [2].

Figure 1. Six week old root cuttings in the greenhouse.

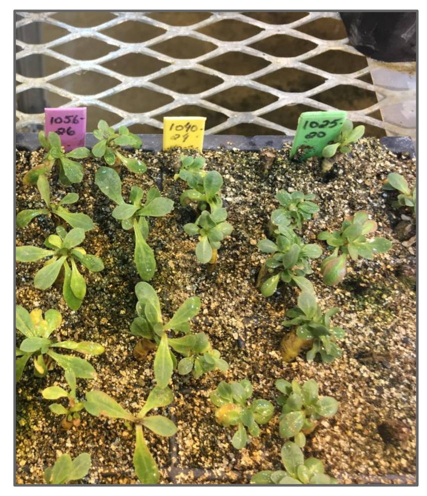

Figure 2. Different completely randomized plot designs were used to plant cuttings in A) Madison greenhouse raised bed, B) Outdoor planting box, and C) Field.

RESULTS

As expected, root size and root rubber concentration were extremely variable (Fig. 3A), but we found that only plants grown in the greenhouse had rosette/root ratios above 1 (Fig. 3B). Plants with this aberrant phenotype were removed from further calculations.

Roots were largest in greenhouse grown plants and smallest in field grown plants (Fig. 4A). The mother and progeny mean root fresh weights were weakly positively correlated except in the field (Fig. 4A), suggesting some heritability of this trait. Progeny root rubber concentration was more strongly correlated to the mothers than root size in plants grown in the greenhouse and the field (Fig. 4B), also indicating weak heritability.

In general, root size and rubber content followed similar trends when compared across the three environments (Fig. 5). Root size (Fig. 5A) was impacted much more by environment than root rubber concentration (Fig. 5B). Mean clonal root size in the greenhouse or planting box was not correlated with size in the field (Fig. 6A), but a correlation was observed between greenhouse and planting box (Fig. 6A insert).

The stability of root rubber concentration in a specific genotype independent of size and environment (Fig. 5B) is consistent with our previous studies, and supports the heritability of this trait [1]. Mean clonal root rubber concentration in greenhouse grown plants was weakly correlated with field grown plants, and not seen in planting box grown plants (Fig. 6B). Mean clonal rubber concentration was not correlated between planting box and greenhouse plants (Fig. 6B insert).

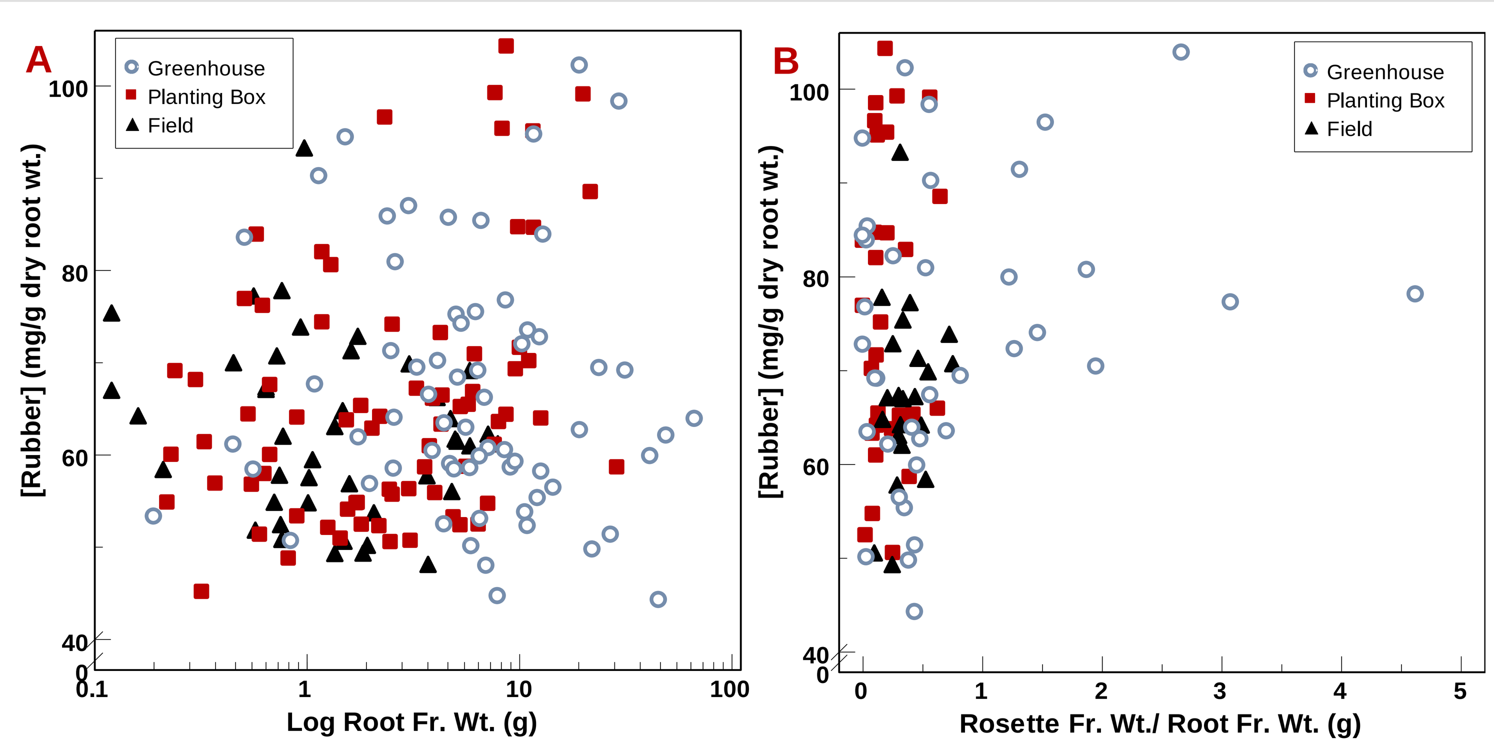

Figure 3. A) Extreme genetic variability of root fresh weight and root rubber concentration was observed in our current TK germplasm. X-axis in log scale to better show range of root weights. B) Plants with rosette/root ratio over 1 are found only in the greenhouse. These plants were removed from subsequent analyses.

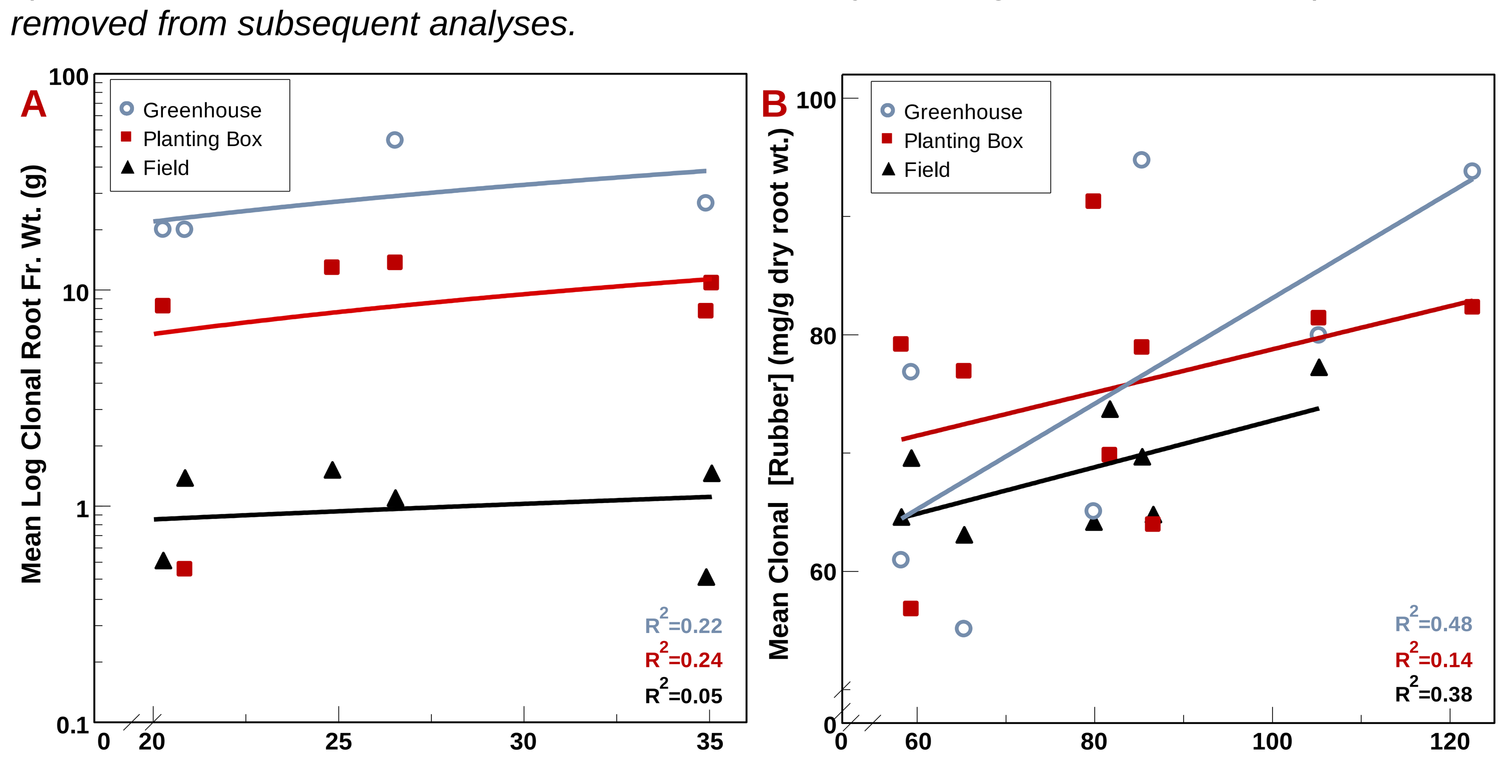

Figure 4. Correlation of clonal and mother mean root A) Fresh weights and B) Rubber concentration by environment. Panel A) Y-axis in log scale to clearly distinguish the range of root weights by environment. The number in each mean ranges from 2-6.

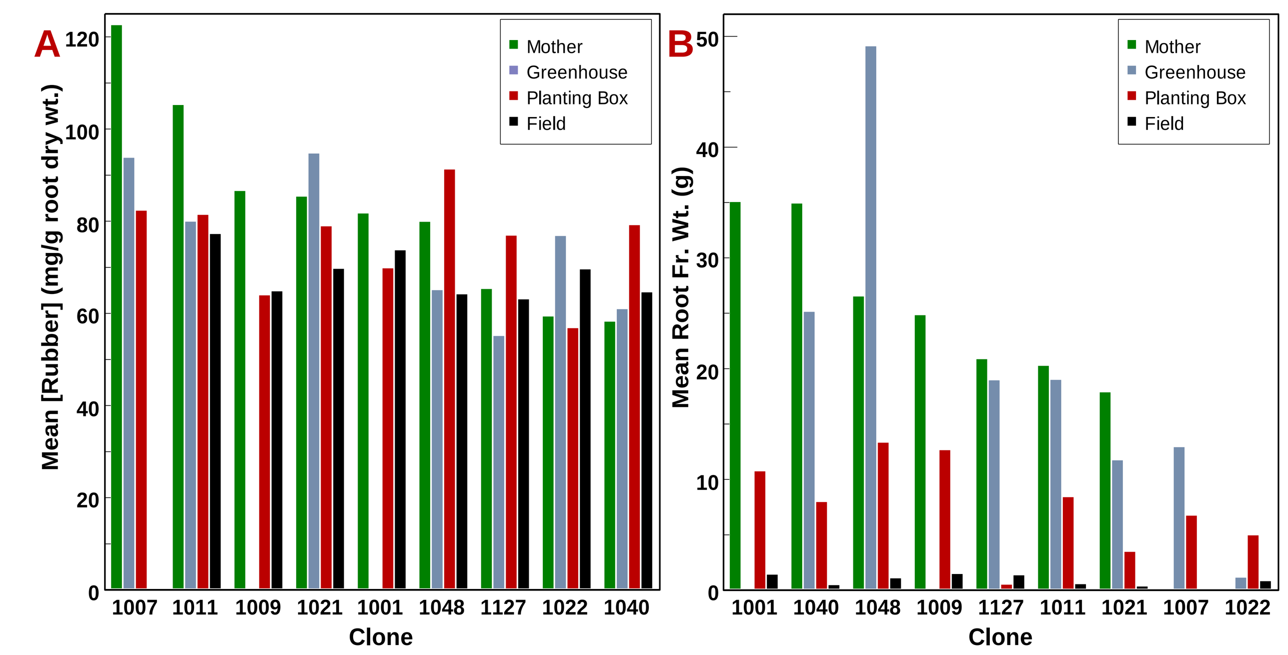

Figure 5. Direct comparison of mean clonal and mother A) Root fresh weight and B) Rubber concentrations across environments. Clones are ranked by mother performance.

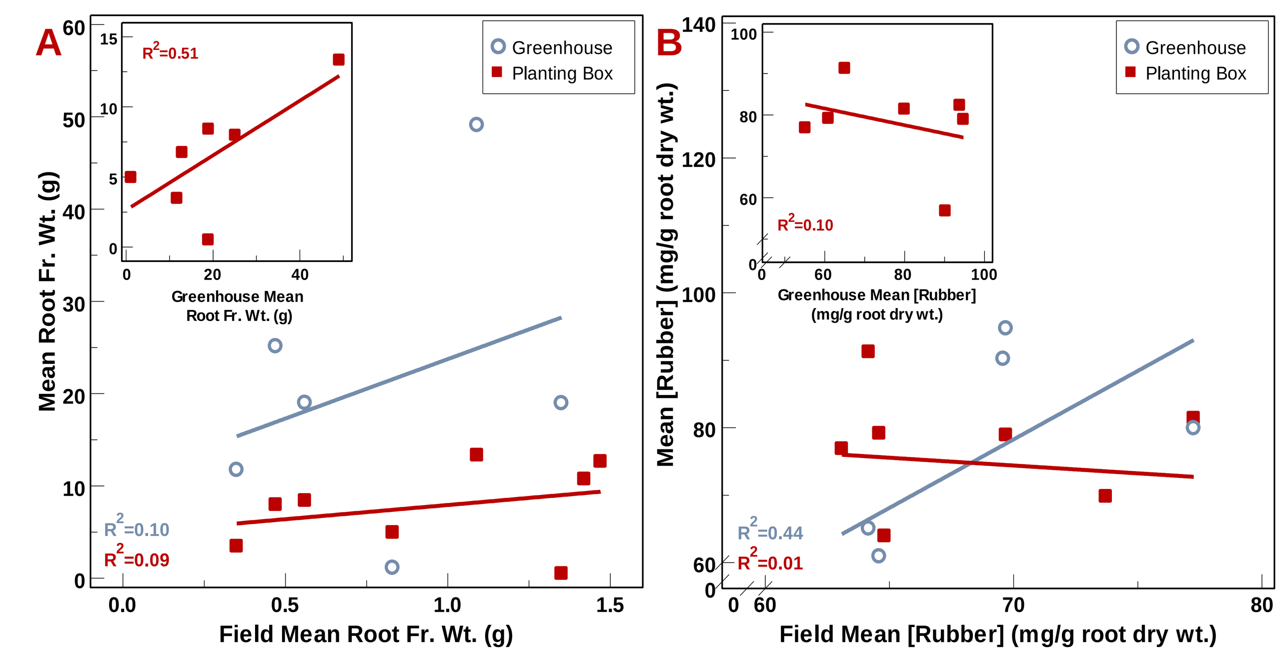

Figure 6. Correlation of A) Mean clonal root fresh weight of greenhouse and planting box plants with field plants, and A insert) of planting box plants with greenhouse plants; B) Mean clonal root rubber concentration of greenhouse and planting box plants with field plants, and B insert) of planting box plants with greenhouse plants.

DISCUSSION

Plant survivorship in all three environments was less than 50%, as plants battled above average summer temperatures, low precipitation, and diseases and pests in the greenhouse. Weed pressure in the field almost certainly caused small plant and root size; biweekly weeding was insufficient.

The low correlations observed in this study are largely caused by very high intra-clonal variation. Genetically identical plants behaved very differently even in the same environment. We suggest that this may have resulted from an uncharacterized positional effect of the original root cutting. It may be possible to reduce intra-clonal variation by using tissue culture to proliferate genetically identical plants of different genotypes. This will be a necessary step before this study can be repeated.

CONCLUSIONS

This study suggests some heritability of both root rubber concentration and root size, however root cuttings are unsuitable clonal material for comparisons among genotypes and environments. Root rubber concentration is much less variable within a clonal genotype than root size across environments. Selection for heritable large plant phenotypes cannot be done in a greenhouse.

ACKNOWLEDGEMENTS

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REFERENCES

1. Cornish, K. et al. (2016) *Biodiversitas* 17.2: 847-856.
2. Cornish, K. et al. (2004) *Industrial Crops and Products* 19: 283-296.