Phenotypic Plasticity and the Invasiveness of Three *Taraxacum* Species

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Introduction

Phenotypic plasticity – the ability of a plant genotype to respond to different environmental conditions by producing different phenotypes – is thought to play an important role in plant invasions.

Invasive species might benefit from phenotypic plasticity in three ways:

1) Jack-of-all-trades: invasive and non-invasive species have similar fitness in favorable environments, but invasive species have higher fitness in stressful environments (Fig. 1a);
2) Master-of-some: invasive and non-invasive species have similar fitness in stressful environments, but invasive species have higher fitness in favorable environments (Fig. 1b);
3) Jack-and-Master: invasives have higher fitness in all environments, but the advantage is most obvious in favorable environments (Fig.1c).

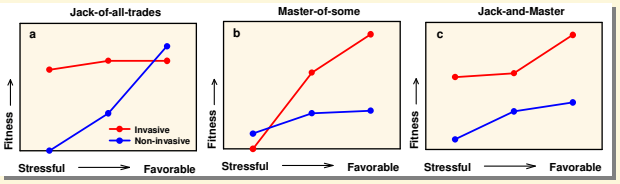


Fig. 1 Three possible phenotypic plasticity strategies for invasive species (red) and non-invasive species (blue). Redrawn from Richards et al (2006).

OBJECTIVE: To test the hypothesis that invasive and non-invasive species differ in their phenotypic plasticity.

TEST SPECIES: Three non-native dandelion species:
Taraxacum officinale (TOF) - a widespread weed (Fig. 2).
T. laevigatum (TLA) – relatively rare in Ohio (Fig. 2).
T. kok-saghyz (TKS) – a potential crop species. A secondary objective was to assess the invasive potential of TKS using comparison results from TOF and TLA.

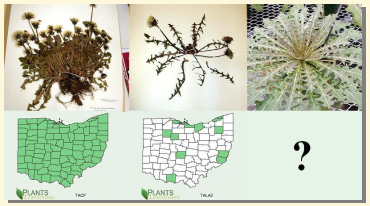


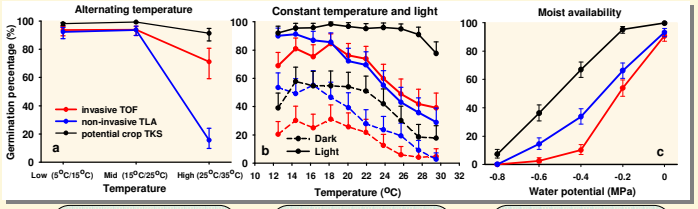
Fig. 2 Morphology of the three dandelions species and their distribution in Ohio: (left to right) the invasive TOF, non-invasive TLA, and potential crop TKS

Materials and Methods

- TOF and TLA seeds were collected from various locations in Columbus and Wooster, OH. TKS seeds were obtained from research materials at Ohio Agricultural Research & Development Center.
- The three species were compared in contrasting environments in three major experiments:
  1 Germination: temperature (alternating or constant), light condition (light vs. dark), water potential gradient.
  2 Greenhouse: light (full light vs. green shade) × soil moisture (dry vs. wet) × soil fertility (high vs. low).
  3 Field: Competition (tall grass, short grass, no-grass) × soil fertility (high vs. low)

Results

Germination Experiment



Stressful (high):
TOF > TLA, TKS: best
Favorable (low and mid):
TOF = TLA, TKS: best
Jack-of-all-trades

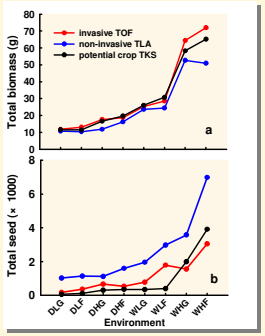
Stressful (dark):
TOF < TLA, TKS: best
Favorable (light):
TOF = TLA, TKS: best

Stressful (dry):
TOF < TLA, TKS: best
Favorable (moist):
TOF = TLA, TKS: best

Fig. 3 Germination patterns of the three dandelions species in different temperature (a and b), light (b) and water potential (c) environments. Error bar shows one standard error.

Greenhouse Experiment

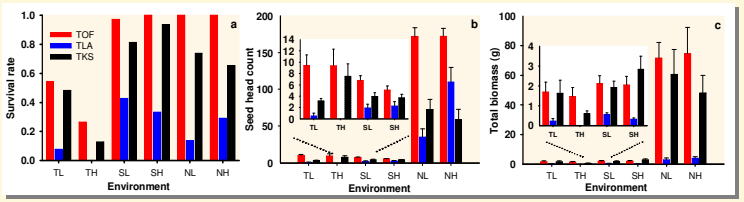
Fig. 4 Biomass (a) and reproduction (b) pattern of the three dandelions species in dry soil (D), or wet soil (W), high fertility (H) or low fertility (L), full light (F) or green shade (G) environments.



Biomass:
Stressful (dry, low fertility, shade):
TOF = TLA, TKS ~ TOF
Favorable (wet, high fertility, full light):
TOF > TLA, TKS ~ TOF
Master-of-some

Reproduction:
Stressful (dry, low fertility, shade):
TOF = TLA, TKS ~ TOF
Favorable (wet, high fertility, full light):
TOF < TLA, TKS ~ TOF

Field Experiment



Survival:
Stressful (tall grass, low fertility):
TOF > TLA, TKS ~ TOF
Favorable (no grass, high fertility):
TOF > TLA, TKS ~ TOF
Jack-and-Master

Reproduction:
Stressful (tall grass, low fertility):
TOF > TLA, TKS ~ TOF
Favorable (no grass, high fertility):
TOF > TLA, TKS ~ TOF
Jack-and-Master

Biomass:
Stressful (tall grass, low fertility):
TOF > TLA, TKS ~ TOF
Favorable (no grass, high fertility):
TOF > TLA, TKS ~ TOF
Jack-and-Master

Figure 5. Survival (a), reproduction (b) and biomass (c) of the three dandelions species in different competitor (tall-, short-, or no-grass) and soil fertility (high or low) environments. Error bar shows one standard error.

Conclusions

- The invasive TOF does differ from the non-invasive TLA in phenotypic plasticity responses to various environments.
- All three strategies (Jack-of-all-trades, Master-of-some, and Jack-and-Master) were identified in different fitness components (germination, growth, and reproduction, Figs. 3, 4, 5).
- The non-invasive TLA exhibited higher fitness under some conditions in germination and greenhouse experiments (Figs. 3 and 4).
- The success of TOF might be attributed to:
  - Germination only in favorable environments (light, moist)
  - Higher biomass accumulation under high resource conditions
  - High survival in all habitats
  - Less reliance on seed reproduction
- TKS performed more similar to TOF than to TLA, which suggests that it has some potential to behave as a weed.

Reference

Richards, C. L., O. Bossdorf, N. Z. Muth, J. Gurevitch, and M. Pigliucci. 2006. Jack of all trades, master of some? On the role of phenotypic plasticity in plant invasions. Ecology Letters 9:981-993

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