

# Plasticity in plant resistance and tolerance to nutrient context

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## Abstract

How plants respond to herbivory may depend on the environmental context in which herbivory occurs. To test this idea we used 9 genotypes of local, field-collected *Solidago altissima* grown in 4 nutrient contexts. These plants were then exposed to variable herbivory from *Melanoplus femurrubrum*, a dominant natural enemy grasshopper collected from the same fields. In general, *S. altissima* exhibited highest induced resistance to herbivores in the highest nutrient context. In contrast, plants grown in low nutrient environments exhibited the highest tolerance of herbivory. Resistant and tolerant genotypes tend to associate with different suites of plant functional traits. Because these traits are a major determinant of decomposition dynamics in ecosystems, divergent trait responses to herbivory may feedback to increase or decrease heterogeneity in nutrient environments and thus impact future plant/herbivore interactions.

## Background

Plant functional traits are a potential tool for linking community composition to ecosystem functioning<sup>1</sup>. However, plasticity in expression of these traits in variable nutrient environments could reduce the utility of the method<sup>2</sup>. I hypothesized that plants may exhibit a switch in defensive strategy from induced resistance (chemical and structural defenses that reduce herbivory through low quality tissue) to tolerance<sup>3</sup> (increase RGR to regain lost fitness, producing high quality tissue), along this gradient. Differences in plant traits between resistant and tolerant phenotypes, may render plasticity in phenotypic expression predictive of whether palatability becomes more variable (1a.) or less variable (1b.) across the landscape when herbivores are present.

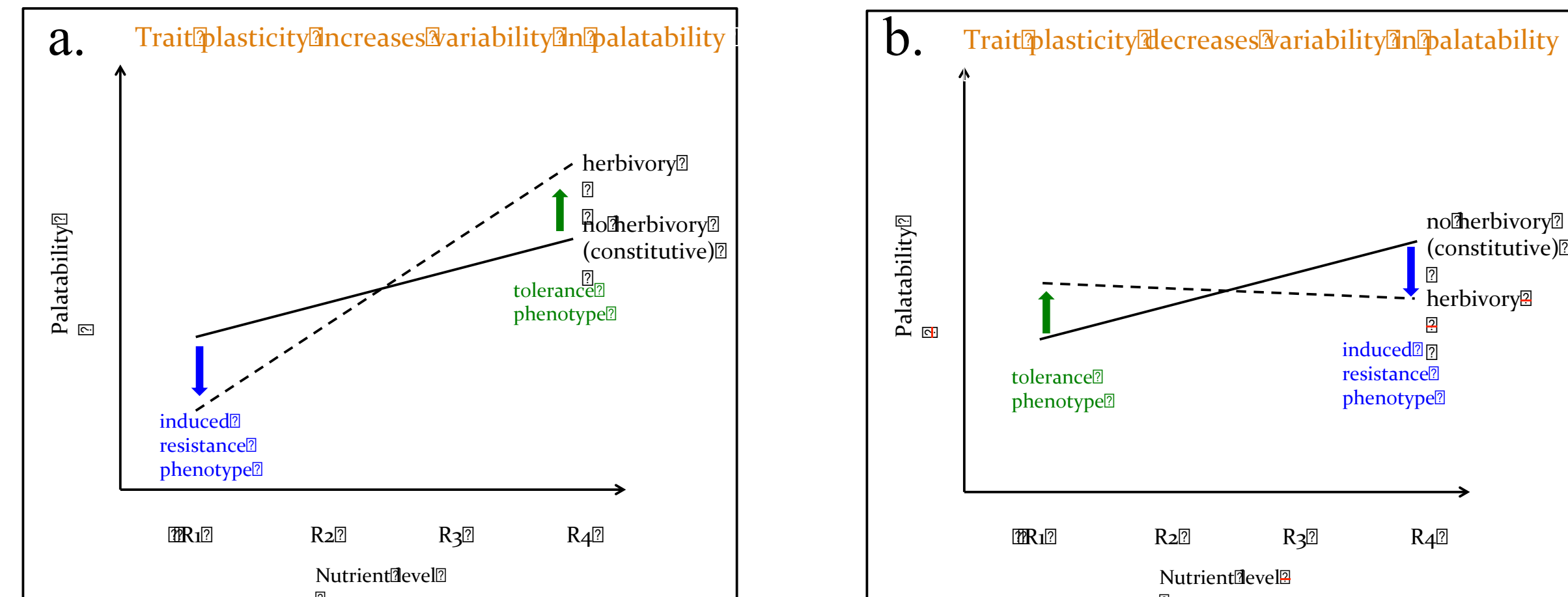
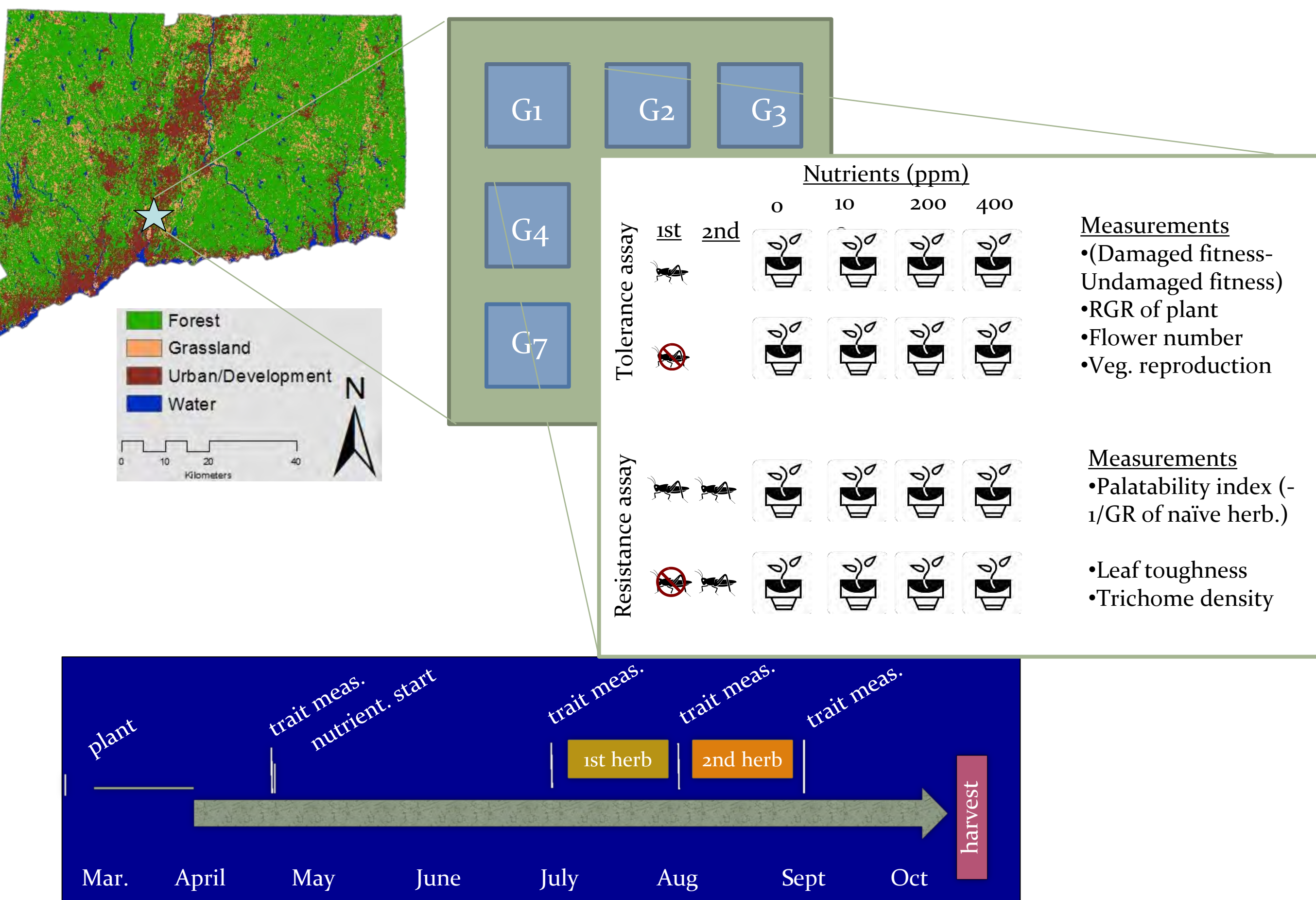


Fig. 1: Hypothesized relationship between plant palatability across a resource gradient with and without herbivory. If plants exhibit induced resistance at low nutrient levels and tolerance at high nutrient levels (a.), then herbivory will potentially increase variation in palatability across the landscape. If tolerance is expressed at low nutrients and resistance at high (b.) then plasticity in the presence of herbivory may stabilize variation in palatability across the landscape.

## Greenhouse experiment design



## A. Induced resistance response

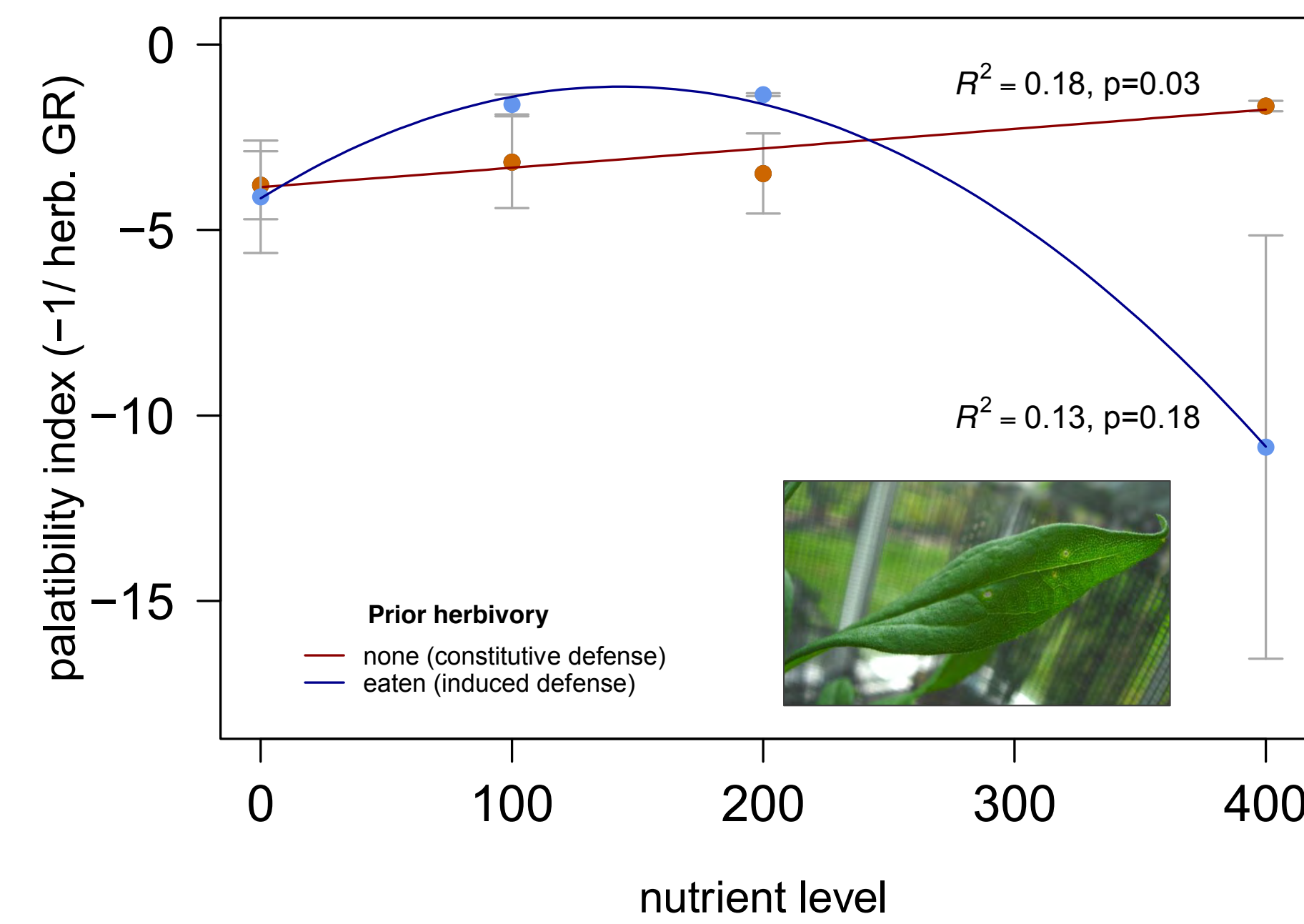
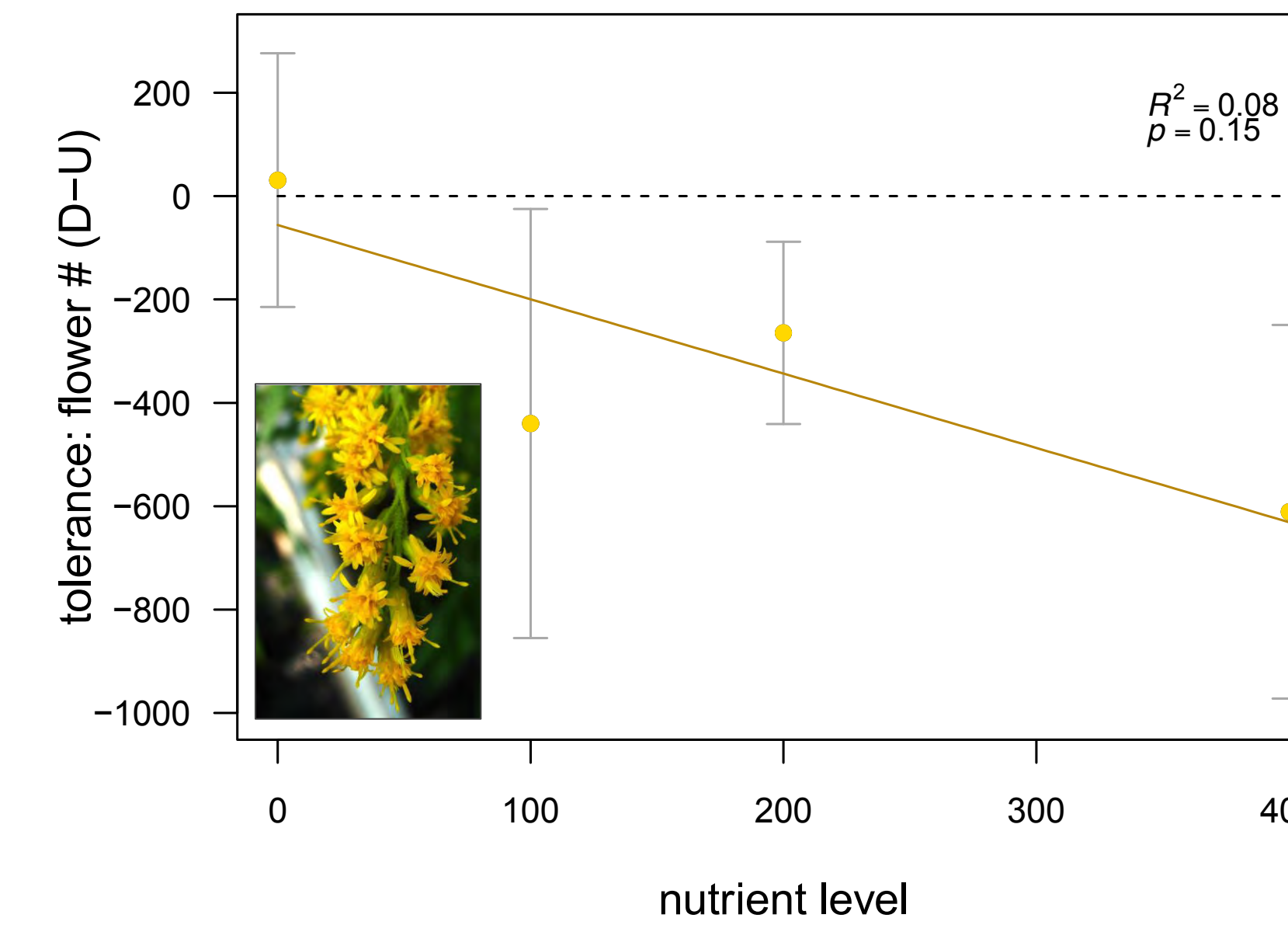
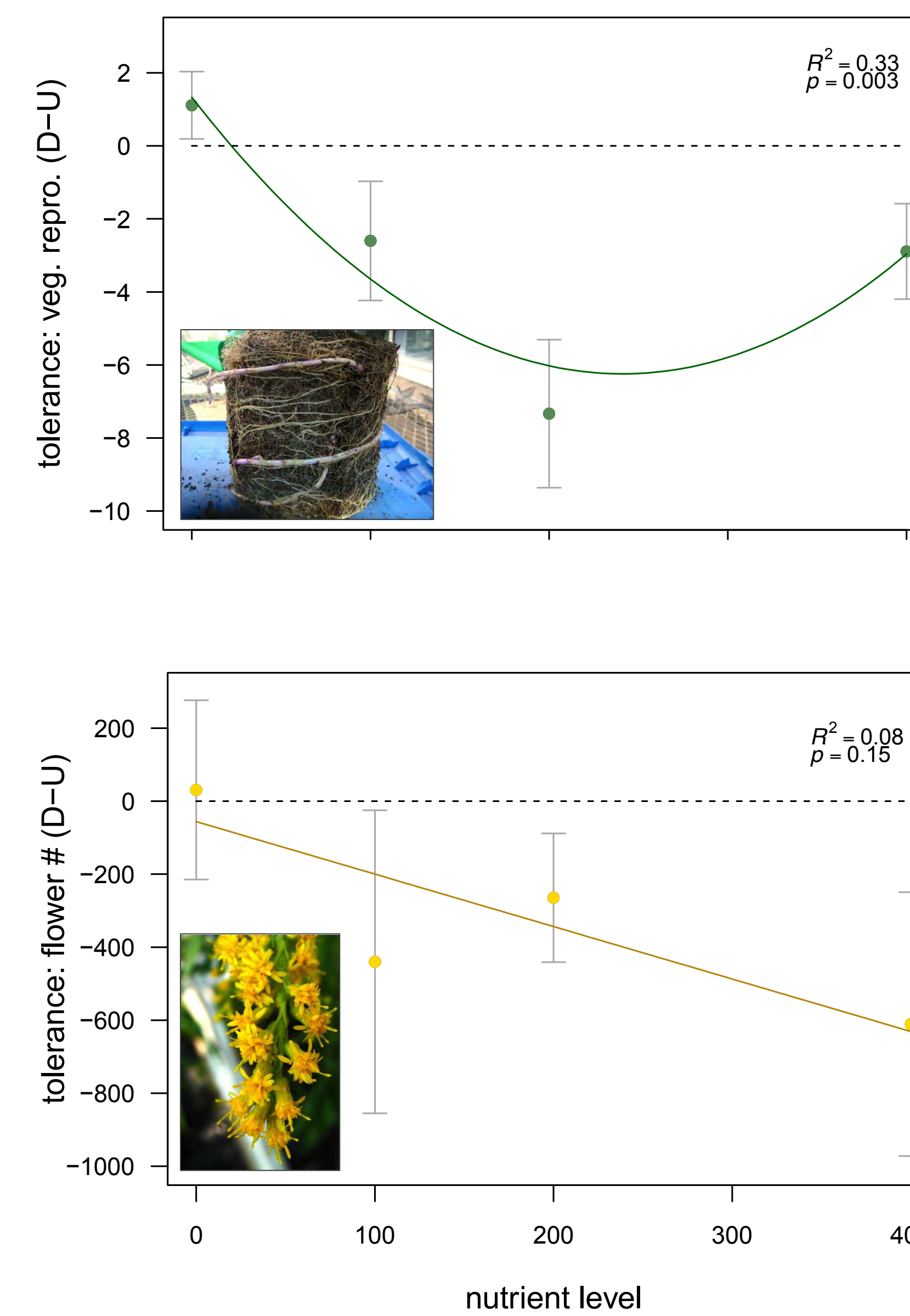


Fig. 2: (a.) Palatability of plants not previously exposed to herbivory compared to induced plants of the same genotypes. Palatability was measured as an assay of herbivore growth rate. Tolerance responses (b. fitness of damaged plant-fitness of undamaged plant) for both vegetative reproduction (asexual) and flower reproduction (sexual) were higher at low resource levels. The dotted line denotes complete compensation for herbivory by damaged plants. Taken together, *S. altissima* expresses an induced resistance phenotype at high nutrient levels and a tolerance phenotype at low nutrient levels matching the prediction illustrated in Fig 1b where plasticity decreases variation in palatability across a resource gradient.

## B. Induced tolerance response



## C. Trade-offs

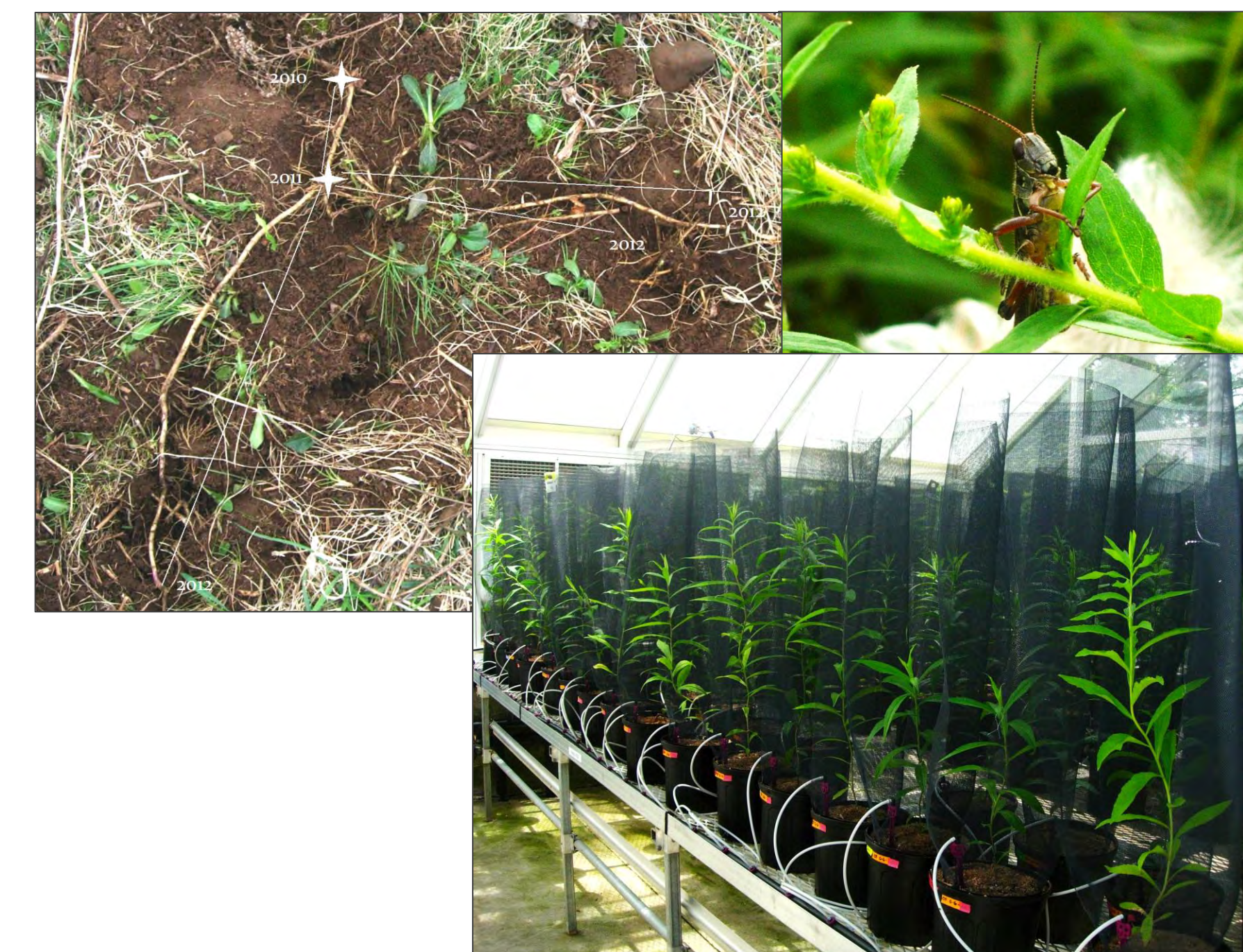
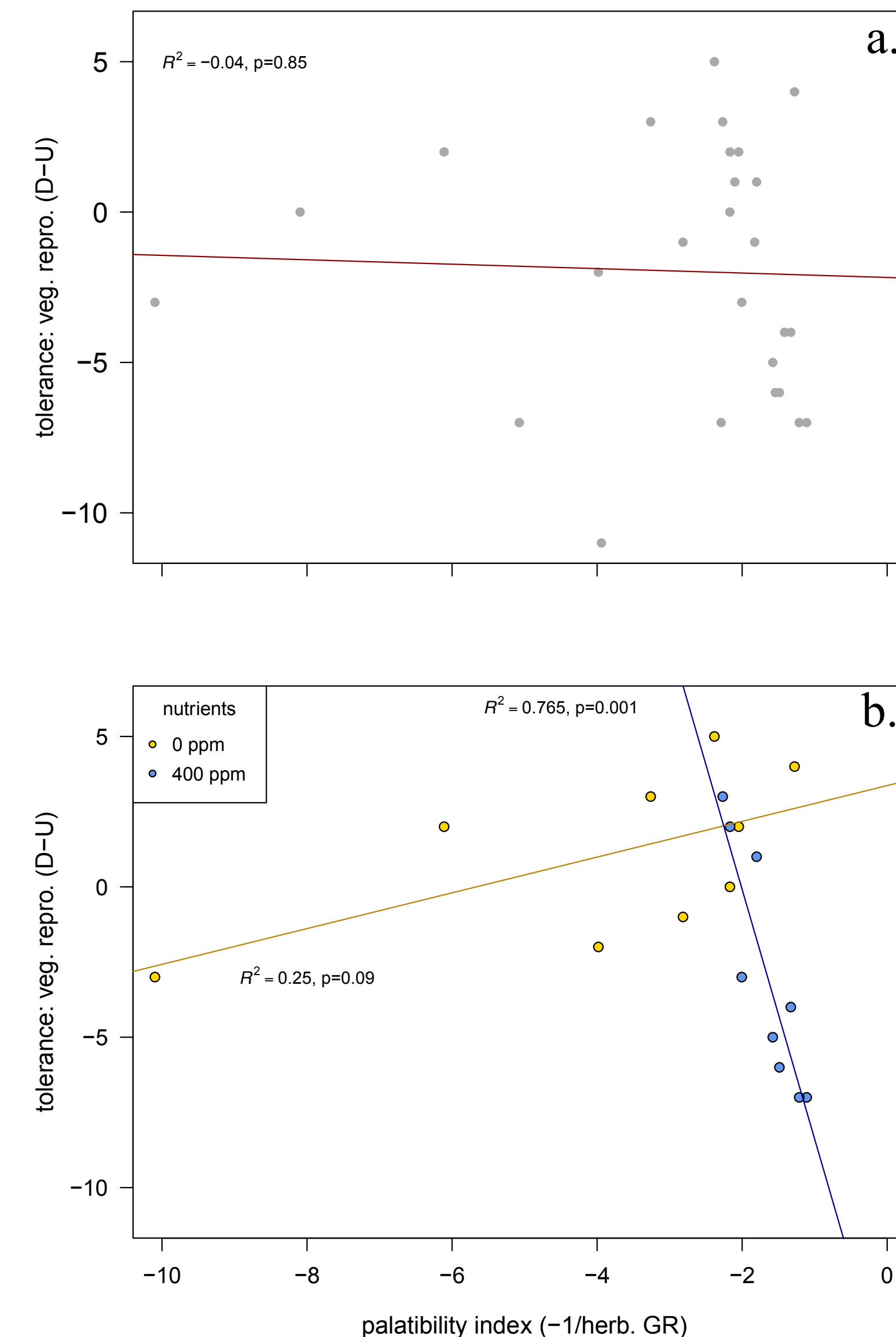


Fig. 3: Nutrient context is critical for identifying trade-offs within *S. altissima*. When the relationship between the palatability index (-resistance) and tolerance of 9 genotypes of *S. altissima* are plotted without regard to nutrient context (a.) no patterns are apparent. When these same data are separated into responses in low (yellow) and high (blue) nutrient contexts (b.), strong patterns emerge. In low nutrient contexts, more tolerant plants are also more palatable exhibiting a trade-off between tolerance and constitutive resistance. The opposite pattern occurs as high nutrient levels.

## Results

- Plants exhibited higher constitutive resistance and tolerance at low nutrient levels
- Induced resistance was much higher at high nutrient levels and exhibited the most variation by genotype at high levels.
- Flower number (sexual reproduction) exhibited more variation in tolerance than vegetative reproduction (asexual).
- The relationship between palatability and tolerance were nutrient context specific. We found a positive correlation at low nutrient levels and a negative correlation at high levels. This relationship was obscured when looking at data across nutrient treatments (Fig. 1a).

## Discussion

*S. altissima* expresses differential defensive responses across a nutrient gradient, perhaps reflecting allocation cost shifts across the gradient. Genotypes exhibited the highest induced resistance in high nutrient environments where costs for defensive compounds are low. Counter-intuitively, tolerance (ability to make up lost fitness potential) was highest at low nutrient levels. This may reflect increased below-ground allocation in low nutrient environments<sup>4</sup>, which allows plants to increase uptake of nutrients more quickly when damaged by herbivores.

In addition, we demonstrate extensive plasticity in plant defense responses to resource environments. We found as much plasticity within a genotype across nutrient environments as we did between genotypes within an environment.

These results show support for the scenario (Fig 1b) where plasticity in plant traits decreases variation in palatability across resource gradients within *S. altissima*.

## References

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