A neighbourhood analysis to characterize competition in a multi-stratum agroforestry system of timber and fruit trees

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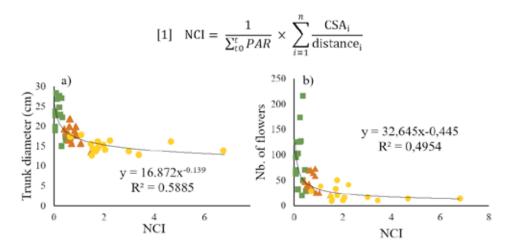
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The growing agroforestry with apple in Mediterranean climate (GAFAM) project looks at the growth and development of apple trees in a multi-strata agroforestry system where walnut trees planted in 1995 forms the upper stratum, three-year-old apple trees the intermediate stratum and sainfoin the herbaceous stratum. Analysing multi-species, multi-stratum agrosystems using a qualitative variable, i.e. 'treatments', is often not satisfying when looking at the heterogeneity within each 'treatment'. Inspired by forest ecologists we developed a neighbourhood competition index (NCI) that combines season-dependant canopy shading and distance-dependent competition model. For $i = 1, …, n$ neighbours within a maximum radius (R=15 meters) of the target tree the net competitive effect of the neighbours on the target tree is given by equation [1].

Where PAR is the sum of the photosynthetically active radiation reaching the crown of the target tree during the growing season (t0…t) and CSA the cross section area at breast height of the neighbour i.

We correlated the trunk diameter of the target trees with the NCI (Figure 1a). The NCI we calculated explained 59% of the variation of the target trees trunk diameter. We then used the NCI to analyse other data like the number of flowers per apple tree (Figure 1b). Our preliminary results will be discussed in the context of the relationships between apple tree architecture and flowering in fruit-tree based agroforestry systems.

$$[1] \quad NCI = \frac{1}{\sum_{t0}^{t} PAR} \times \sum_{i=1}^{n} \frac{CSA_i}{distance_i}$$

[1] Equation used to calculate the NCI. a) Correlation between the trunk diameter and our newly calculated NCI of 45 3-year-old apple trees across a range of walnut-apple. b) One example of data analysis using the NCI. Here we correlated the number of flowers per tree for 45 apple trees with the NCI. NB: increasing NCI values means increasing competition.

Keywords: Agroforestry, Apple tree, Competition, Neighbourhood competition index, Mediterranean climate.

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