

QBS-e Index, a tool based on earthworms for assessing the soil quality in agroecosystems and recent applications

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Introduction

Earthworms are one of the key taxonomic groups in the soil¹. They play an important role both in the improvement of the structure and porosity, through the creation of tunnels², and in the enrichment of macronutrients and recycling of the organic substance³. These characteristics give a high ecological value to earthworms, which are universally considered bioindicators of soil fertility and the impact of agricultural practices^{4,5}. The greatest activity and composition in species and categories were found in environments with little disturbance and high vegetation conservation^{6,7}. Through the study of biodiversity, it is possible to know the state of health of an agroecosystem and, the use of specific, rapid, and effective indices is fundamental for this practice^{8,9}. To more quickly measure the ecosystem service of earthworms in agroecology concerning agricultural practices, the QBS-e Index was proposed¹⁰. Through the years, this tool has been tested and improved in 2018¹¹, subsequently used in Italian agricultural agroecosystems. The final value of QBS-e is directly proportional to the degree of conservation of the site considered, and to the consequent soil quality class. This study aims, by briefly presenting the method underlying the Index to show the results collected in recent years of utilization and possible future developments by proposing a worldwide collaboration to detect the state of the art of this tool.

Methodology

The QBS-e Index is based on the number of earthworm specimens collected using a hand-sorting method with known soil surface and converted in squared meter, their ecological category, and stage of development and replications information. A specify created EMI (Eco-Morphological Index) score⁹ has been attributed to each ecological category and age of the earthworms collected (*Tab 1*). For the final QBS-e value, it is necessary to multiply the different EMI scores for the abundance of specimens collected by applying the following formula

$$\text{QBS-e} = (\text{HYD } j, \text{ad} \cdot N) + (\text{COP } j, \text{ad} \cdot N) + (\text{EPI } j \cdot N) + (\text{END } j \cdot N) + (\text{EPI ad} \cdot N) + (\text{END ad} \cdot N) + (\text{ANE } j \cdot N) + (\text{ANE ad} \cdot N)$$

where in the capslock the EMI score of the ecological categories and N to the mean number of specimen for each ecological category per m² in the raplicates

At the end, to evaluate the soil quality soil is necessary to refer to the QBS-e value calculated with the corresponding soil quality class (*Tab 1*). In case of recovery of immature specimens impossible to attribute to a specific ecological category, you may assign them to the most abundant of specimens or the lower category in terms of quality.

Tab 1, EMI scores for the ecological categories and Soil Quality Classes

Ecological category	Age	EMI score
Hydrophilic (HYD)	Immature (Im)	1
Hydrophilic (HYD)	Adult (Ad)	1
Coprophagic (COP)	Immature (Im)	2
Coprophagic (COP)	Adult (Ad)	2
Epigeic (EPI)	Immature (Im)	2.5
Endogeic (END)	Immature (Im)	2.5
Epigeic (EPI)	Adult (Ad)	3
Endogeic (END)	Adult (Ad)	3.2
Anecic/Deep-burrower (ANE)	Immature (Im)	10
Anecic/Deep-burrower (ANE)	Adult (Ad)	14.4

QBS-e value	Soil Quality Class
QBS-e > 1000	Excellent (4)
600 < QBS-e < 1000	Good (3)
300 < QBS-e < 600	Decent (2)
100 < QBS-e < 300	Sufficient (1)
0 < QBS-e < 100	Poor (0)

Fig 1. QBS-e value in Horticultural and their margins

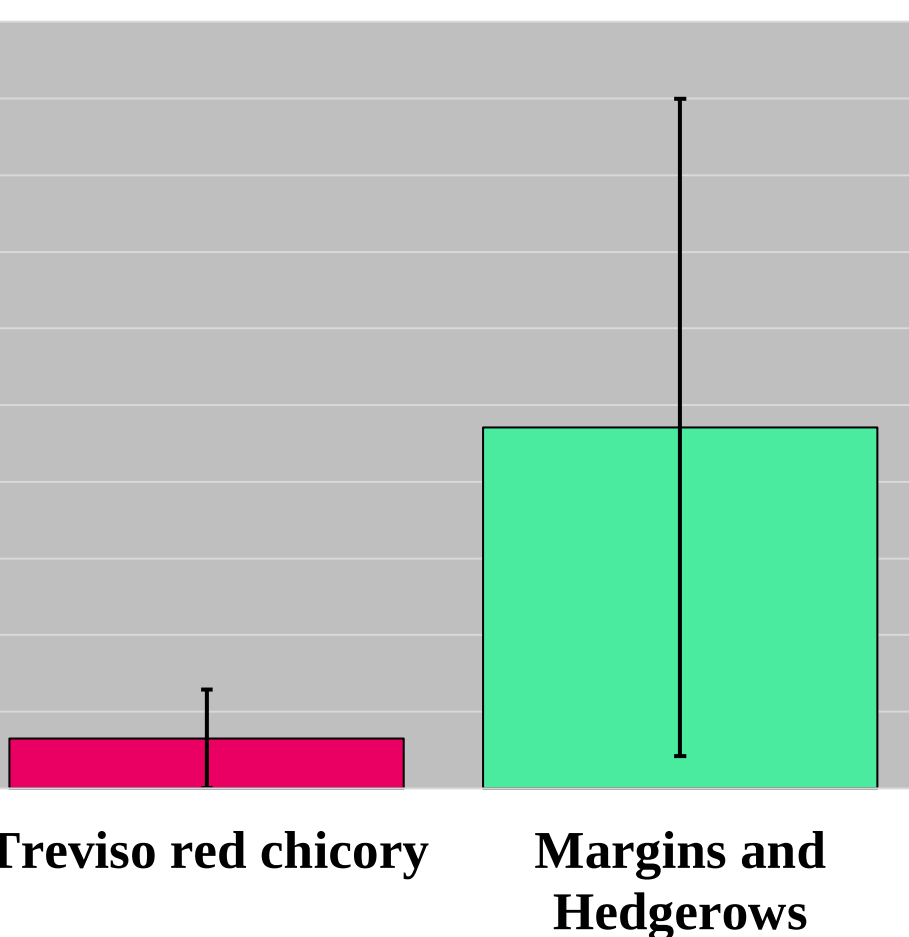


Fig 2. QBS-e value in Cover Crops

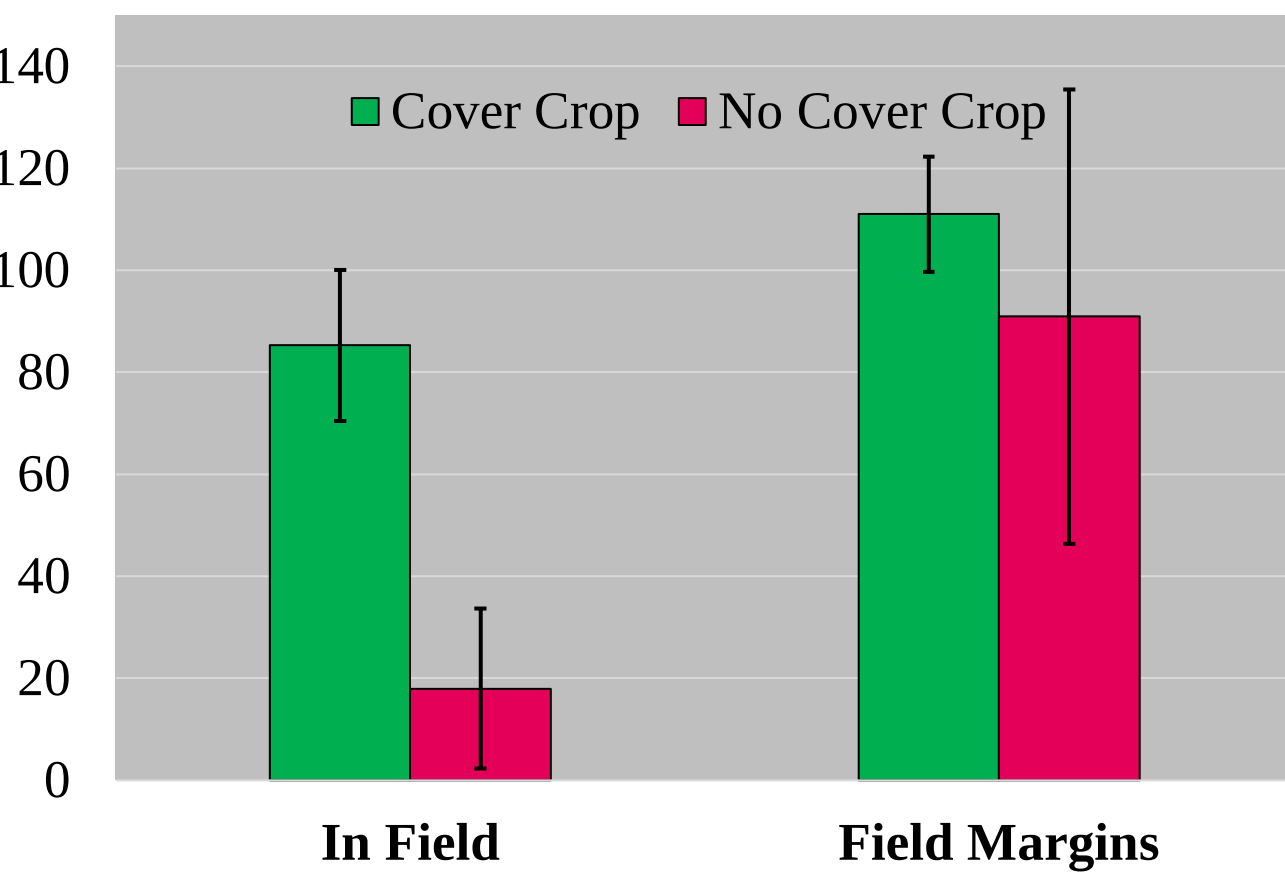


Fig 3. QBS-e Values for tillage in orchard¹⁰

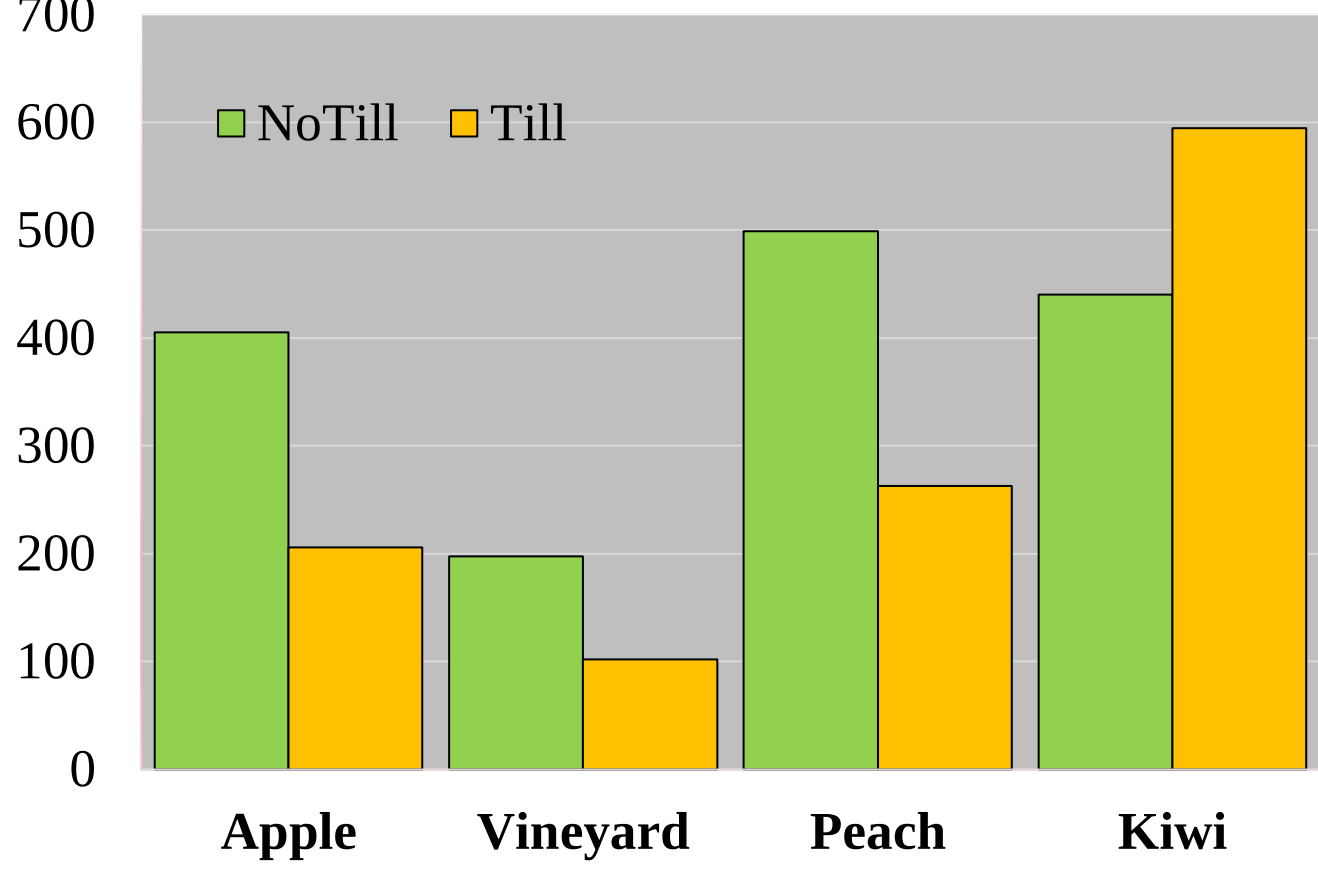


Fig 4. QBS-e values for tillage in orchard

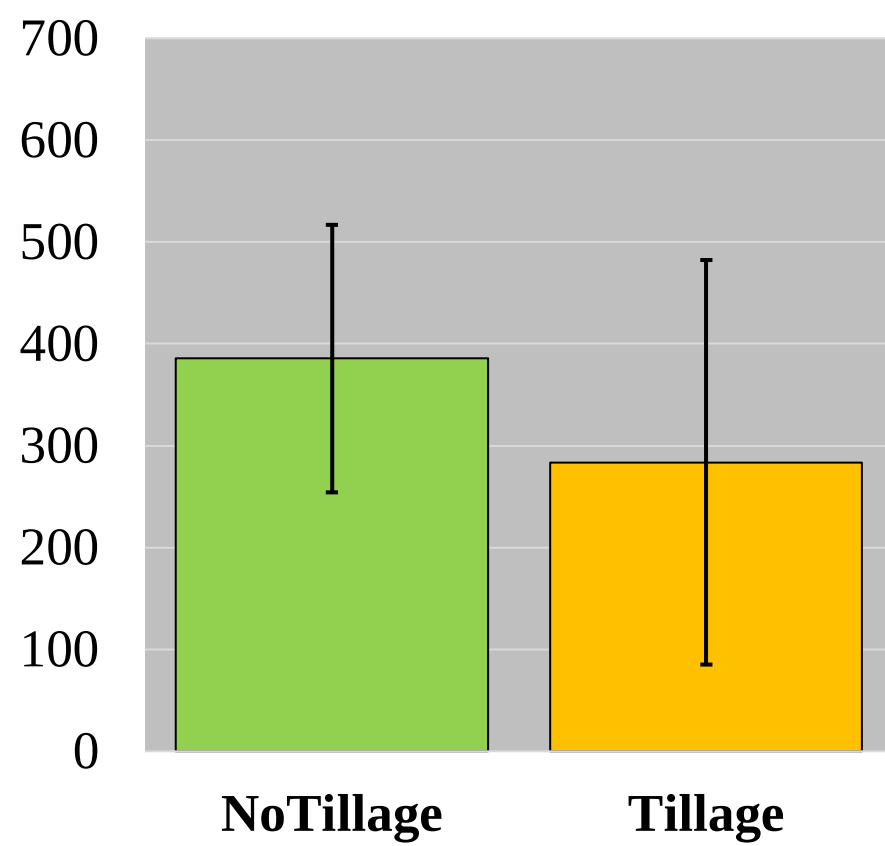


Fig 5. QBS-e value for Agricultural Management

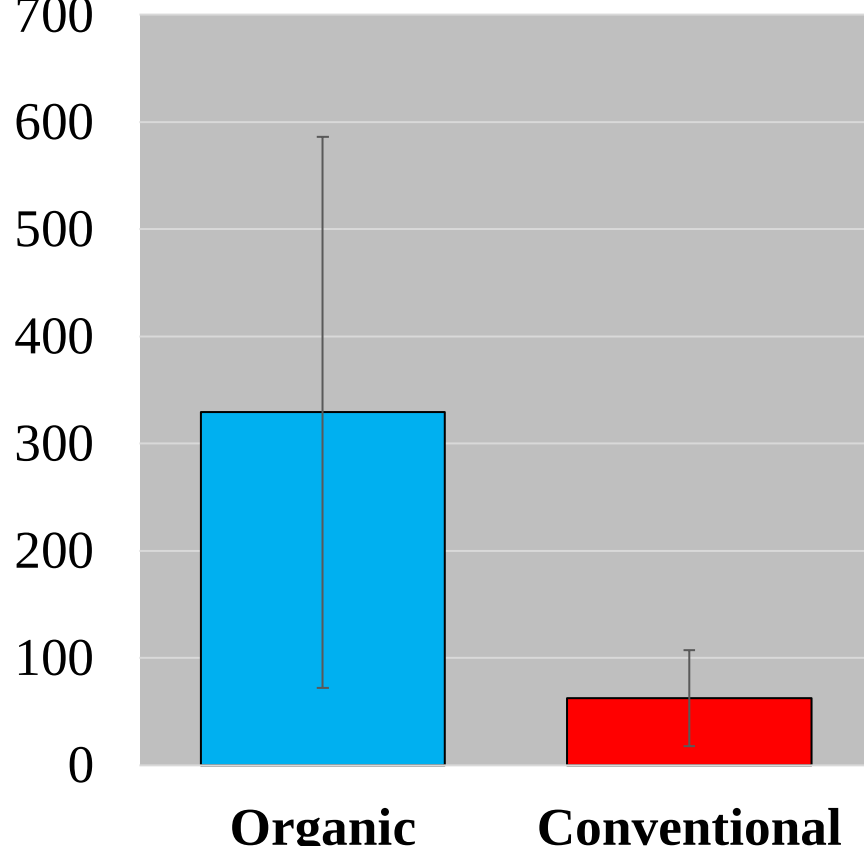
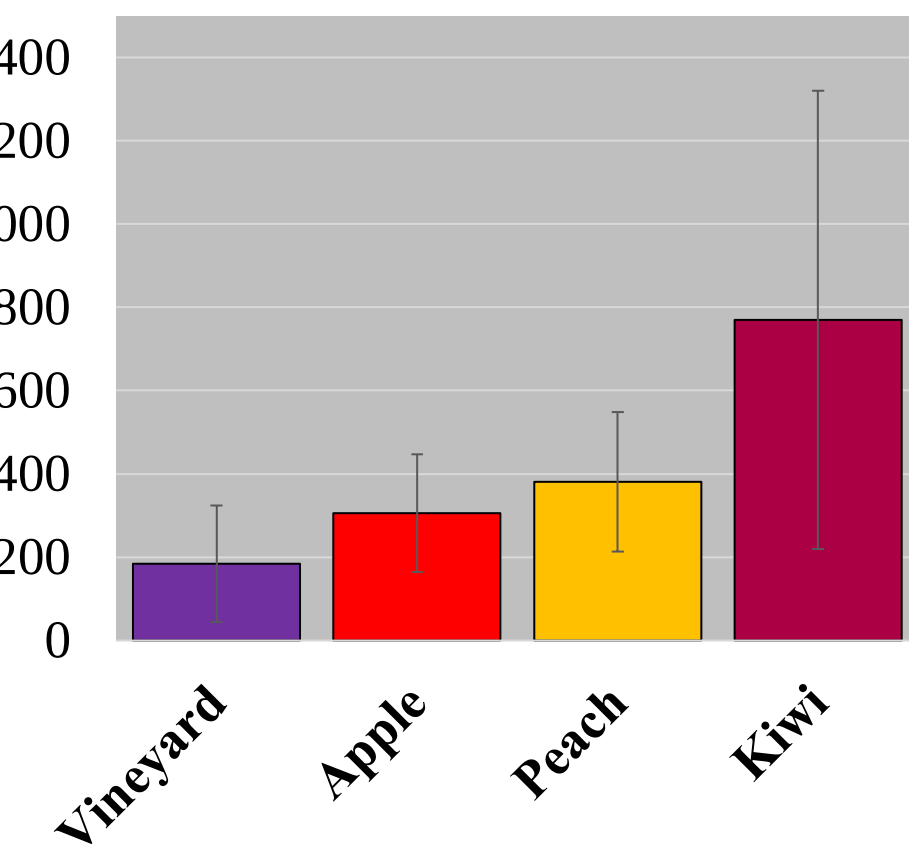


Fig 6. QBS-e value for types of orchard



Results

Collecting and re-analyzing the available data from the studies of the last few years the values recorded in the publications^{10,11} are reconfirmed:

- differences in QBS-e scores is observed between types of environment. Higher values are found in concomitance with semi-natural environments near agroecosystems and in the presence of marginal vegetation (*Fig 1*);
- a trend in soil quality values is observed which is directly proportional to the presence of marginal vegetation and higher values are found in conditions in which the external vegetated spaces coincide with the presence of cover-crop vegetation in which and where cover-crop are present (*Fig 1, 2*);
- management differences are found concerning conservative agronomic practices (tillage, presence of cover-crops and Organic-Conventional Management) (*Fig 2, 3, 4, 5*);
- different values in the types of environment are observed : Treviso red chicory, vineyards, field margins, orchards, and external vegetation and different trends are observed in types of orchards (*Fig 6*);

Discussion and Conclusion

The QBS-e is an effective practice for evaluating an agroecosystem. Through the development of the QBS-e Index:

- the quality of the agricultural ecosystem can be monitored with good effectiveness, photographing its variations before or after mechanical interventions, disturbances, or disasters;
- it is possible to discriminate not only the degree of conservation, but also the differences in management relative to the levels detected in the surrounding landscape and the results recorded in recent years; this poster remains in line with the results found in the 2018 article;
- this Index allows the detection and analysis of the composition and distribution of the earthworm and of the ecological categories;
- due to its practicality, it is suitable for farmers and agricultural operators to obtain quick information on the conditions of the soil;
- due to the degree of use, practicality, development, and information, it is also suitable for researchers in the sector as it can summarize several parameters, facilitating the general reading of the ecosystem and statistical analysis.

The 2018 publication was accompanied by ad hoc software available free upon request which, with ease, quickly returns the index value and the number of items per square meter useful for statistics, by inserting simple elements. Since the date of publication, this software has been requested by 23 research groups in 18 countries of the world, therefore we know that it has been used in the world and some cases have already been cited by scientific papers.

Proposal

For the 10th anniversary of the Index, research groups that have requested and used the index in recent years have been proposed to be able to participate in a comparative study of the results found, to evaluate the state of the art. Through this open participation and the potential of the index, improvements and developments will be possible like the way to standardize the results based on the analyzed environment to have a better reading in the qualitative comparison of different environments and face an easier approach in the calculation.

References

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