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Mobile and Web Apps as Tools for Weed Identification

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Introduction

The ability in identifying weeds at different growth stages can be useful both for research purposes and for developing appropriate weed control strategies. Weed surveys are often carried out to map the distribution of certain weeds in different environments, such as the spreading of invasive alien species, to correlate weed presence with pedo-climatic characteristics or with different agronomic techniques (Lapinsh et al., 2008). Weed identification is also an important skill for agronomists and farmers in general as it permits to choose the most appropriate management techniques, such as the most effective herbicides, to detect the weeds that most affect crop yield and to adjust weed control plans against these species (Vidotto et al., 2016). Weed identification is a difficult task as the plant appearance varies as a response to different environmental conditions, such as soil type, climate, and as a consequence of plant growth (Leminem Madsen et al., 2020). Recently, the widespread availability of computers and smartphones has made possible the development of web applications based on machine learning softwares even for plant recognition and mapping (Wäldchen and Mäder, 2018). These automated identification systems are now reliable tools for identifying organisms even though their ability strongly depends on the quality and precision of the image sets used to train the identification system. Some of the most popular applications arise from projects that aim at identifying organisms and recording their presence in the environment with the help of common citizens that made and upload observations on the platforms (citizen science projects).

Among these, there are some apps developed for specific scientific projects, such as CSMON-Life which is linked to a European project with the objective of mapping the distribution of alien and rare species (Csmon-life, 2020). Another application is Pl@ntNet that is a citizen science project that helps identifying plants and map biodiversity (Pl@ntNet, 2020), while iNaturalist is both a species identification system and a tool for recording organisms with the aim of acquiring biodiversity data and make them available for the scientific community (iNaturalist, 2020). These apps also allow any users to help in identifying observations uploaded by other observers and train the software for future identification of the same species. When an uploaded observation is geolocated, it has at least one image of a spontaneous organism and at least 2/3 of the people that help in identifying the species have confirmed the specie attribution, the observation acquires the “research status” and became part of the database that teach the algorithm for species identification.

The objective of the present study had the aim of verifying the possibility of using the application iNaturalist for weed identification, initially considering the weeds already present in the database.

Materials and Methods

At the beginning of 2020, a project called “Malerbe d’Italia” (Weeds of Italy) under the platform iNaturalist has been launched (https://www.inaturalist.org/projects/malerbe-d-italia). Eighty-nine weed species were chosen both among the most common weeds infesting crops in Italy and among species present in non-crop areas. The projects present on iNaturalist permit to automatically group observations that have certain characteristics, such as those that are related to specific taxa, or those recorded in a specific location. The criteria set for creating the project were that of including all the observations present in the database relative to the chosen weed species but only if they were recorded in Italy.

Afterward, all the observations present in the project were downloaded in an electronic file that included, for each observation, the scientific name of the species, the GPS coordinates, the name of the location and the date in which the species was observed, the name of the observer, the research status (or not) of the observation, and additional notes if present. The file was then imported as shapefile in QGS, an open

source Geographic Information System that allows to create maps of geolocated data. This software was then used to create distribution maps of the different weed species present in Italy. Moreover, for each species, the number and the characteristics of the observations were analyzed.

Results

The project "Malerbe d'Italia", at the beginning of May 2020, comprised of more than 10,800 observations of 86 weed species recorded by about 2,800 observers, while about 940 people helped in identifying the species.

The species that recorded the highest number of observations were *Veronica persica*, with more than 830 records, *Malva sylvatica*, *Lamium purpureum*, *Papaver rhoeas* and *Phytolacca americana*. These 5 weeds were those for which were recorded at least 500 observations. The lowest number of observations was instead recorded for *Panicum miliaceum*, *Amaranthus hybridus*, *Cuscuta europaea* and *Phalaris paradoxa*, all having only 2 observations since the start of the project. It should be noted that the most observed species were in general those having colored and showy flowers, or well-known species such as *Urtica dioica*. On the contrary, the least observed species were those difficult to identify, less common in the environment and often pertaining to grass weeds with less showy flowers.

The majority of the observations only included a plant image, which often represents the flower, while on average each observation had 2 images. Images of seedlings were taken only rarely and thus the algorithm is not well trained in identifying weeds at this growth stage. The highest number of observations were recorded in non-crop areas as the app users were mainly common citizens which recorded observations in natural areas or along the roads.

Conclusions

The experience gained with this project has permitted to understand that iNaturalist app, or similar ones, are useful tools for identifying weeds and perform weed distribution surveys. However, some limitations still exist, such as the scarcity of seedling images as well as of observations recorded from cultivated fields. The creation of specific projects that will include seedlings observations of crop weeds, even with the help of agronomist and technicians, will contribute to train the algorithm in identifying weed seedlings. Participatory researches and citizen science projects have the advantage of raise public awareness on certain topic, such as the importance of identifying and mapping weed distribution. Moreover, as weed survey are generally time consuming and costly, these citizen science projects can help in reaching the goal more quickly. A previous study that aimed at mapping different bamboo species in Piemonte, using observations uploaded on iNaturalist by technicians and citizens has reported that to record more than 900 observations about 14,500 km were travelled and it has estimated that the participatory project has permitted to save the work of 2 people for about 60 hours, for a total cost of about 27,000 € (Lonati, 2019). The availability of web and mobile apps could be a new tool to help weed scientists and agronomist in identifying weeds and carrying out weed surveys; moreover, the contribution of citizens in scientific projects will increase public awareness on important agricultural topics.

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