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Cardoon As a Biorefinery Crop for Marginal Areas in Tuscany: the EIP-AGRI Operational Group GO-CARD

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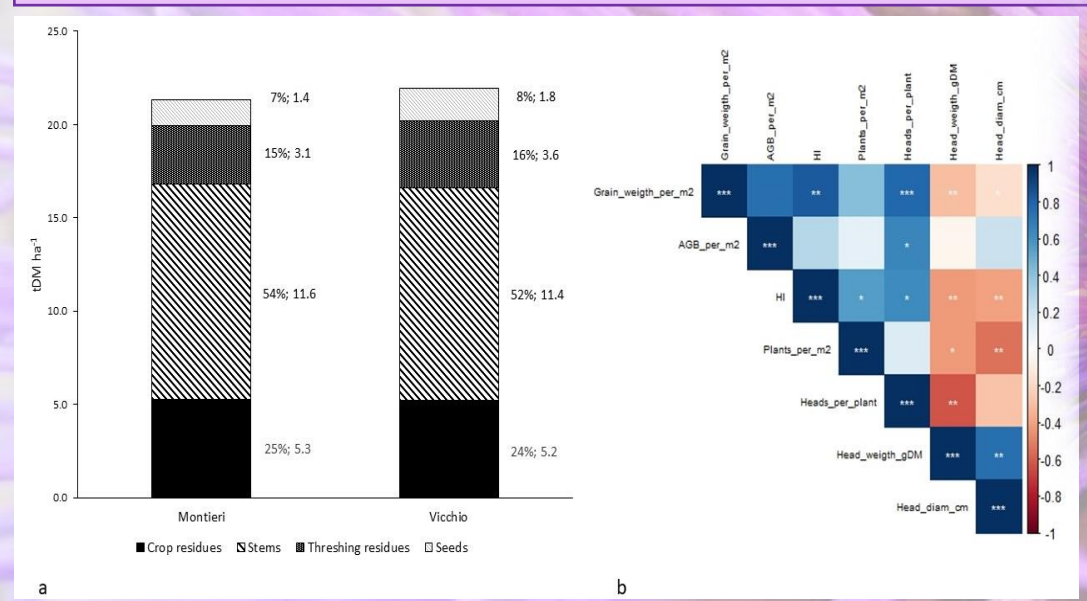
Introduction Cardoon (Cynara cardunculus L.) is a perennial herbaceous C3 species adapted to Mediterranean rainfed environments. A potential double-purpose bioenergy crop: seed oil production and lignocelullosic residues as bionergy feedstock. *Advantages*: perennial character, strong tap root system and low damage rate by wild boars. *Open questions*: which marginal soils are better exploited (clay versus sandy); which sowing time is the most appropriate (in spring or winter); which biomass residue management guarantees the economic sustainability.

Objective The objective of the GO-CARD project is to assess the agronomic performances and profitability of the cardoon cultivation in different marginal areas of Tuscany.

Materials and Methods Five field trials established in spring 2019: four in Southern Tuscany and one in Northeastern Tuscany. Seedbed preparation: ripper followed by a rotary harrowing. Fertilization before sowing: 100 kg N ha^{-1} and 50 kg P_2O_5 ha^{-1}. Cardoon (Cynara cardunculus L. var. altilis, Trinasid) was sown in April 2019 with a precision seeder: 10 seeds m^{-2} with a precision seeder (0.75 m inter-row spacing). In 2019 the crop did not flower and it was mowed in August. In April 2020 the late frost blocked the early flowering stages in Monterotondo Marittimo and Pomarance sites (North-Northeast aspect, clay-loam texture). In Montieri and Vicchio sites (flat area, sandy-loam texture), the harvesting was performed (end of August 2020) with wheat and sunflower combined harvesters, respectively for the two farms. At harvest the plant density, the grain yield and the biomass partition, including litter, were assessed in 5 sampling plots per field (2 m^2). The dry matter content of seeds, heads, stems and litter was determined by oven drying until constant weight. In each sampling plot, the head diameter, the number of heads per plant and the average grain yield per head were measured.

Results The Figure *a* reports the grain yield and the biomass partitioning of cardoon in the two sites of Montieri and Vicchio. The grain weight did not show a statistically relevant correlation with the aboveground biomass, suggesting that plants producing a high amount of biomass are not necessarily highly productive (Figure *b*). The grain weight showed a positive correlation with the number of heads per plant, while it showed a negative correlation with the average dry weight and diameter of heads. The average heads dry weight was also negatively correlated with the number of heads per plant and the plant density, as well as the heads diameter was negatively correlated with the plant density. Finally, we observed a positive correlation of the harvest index with the grain weight, the plant density and the number of heads per plant. Conversely, the harvest index negatively correlated with the heads dry weight and diameter.



Conclusions Only in two out of five sites the crop reached the maturity. The reasons are the following:

- soil texture and terrain aspect should be considered carefully for the cardoon establishment
- sandy soils showed to be more suited respect to clay soils
- the Northeast aspect increased the risk of crop failure due to a higher vulnerability to late frosts

These preliminary results showed that:

- the very low harvest index in contrast with a high production of lignocellulosic biomass suggest the suitability of cardoon as a double-purpose crop
- the grain yield proved to be positively affected by the heads density per unit area much more than the head size and ripening

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