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Circular agricultural system in safflower: agronomic practices and oil extraction environmental impact

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Introduction

• In the circular economy framework safflower (*Carthamus tinctorius* L.) cultivation would guarantee different outputs (main products and co-products) under low-input or marginal cultivation compared to other oilseed crops (i.e., sunflower)

• In Italy, safflower cultivation requires the development of adequate cultivation technique and accurate assessment of the deriving environmental impact

AIM: identify the **best genotypes** suitable for industrial purpose and **cold tolerant** in case of **autumn sowing** to allow a reduction in water consumption compared to spring sowing.

Materials and Methods

Treatments:
- 3 cultivars (high oleic acid): **Saff_1, Saff_2, Saff_3**
- 2 sowing times: autumn (**_Aut** tr) , spring (**_Spr** tr)
- 2 growing seasons (2018/2019, 2019-2020)
- factorial design with 3 reps (21 m^2 per plot)

Crop cultivation:
- site: FieldLab of the University of Perugia
- sowing date: 18-Oct-18 & 1-Oct-19 for _Aut tr, 28-Mar-19 & 1-Apr-20 for _Spr tr
- sowing density: 50 plant m^{-2}
- fertilization: 80 kg P_2O_5 ha^{-1}, 100 kg N ha^{-1}
- maturity: 290 (_Aut tr) and 140 (_Spr tr) days after sowing

Measurements:
- weather conditions
- achenes yield and total aboveground biomass
- biometric traits of plant and achenes
- LCA from cultivation to final oil production vs sunflower oil
- reduction of impact using the cake for feed purpose

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Results

•wheater conditions: abundant rains in autumn-winter (410 mm), moderate in spring season (173 mm), as 2-year average; severe frosts in Jan-19 (<-6°C), in Feb-20 (-6°C) and April-20 (-3,4°C)

Table 1: Plant density at harvest, plant biometric traits and yield of safflower grown in 2018/2019 (1st y) and 2019/2020 (2nd y). SED, standard error of the difference.

Treatments	Plants m^{-2} (n°)		Plant height (cm)		Capitula $plant^{-1}$(n°)		Yield (t ha^{-1}, dw)	
	1st y	*2nd y*	*1st y*	*2nd y*	*1st y*	*2nd y*	*1st y*	*2nd y*
Saff1_Aut	54	27	172	111	17	25	2.1	2.0
Saff1_Spr	47	54	127	100	17	13	1.5	1.1
Saff2_Aut	25	16	137	105	22	21	1.9	2.0
Saff2_Spr	30	49	103	82	10	10	1.7	1.0
Saff3_Aut	27	12	146	103	18	28	1.7	1.4
Saff3_Spr	48	49	122	88	9	9	2.0	0.4
SED	*1.9*	*5.5*	*6.65*	*3.43*	*4.0*	*4.4*	*0.12*	*0.27*

• frost damages occurred in _Aut tr. especially in the 2nd year: n° plants m^{-2} at harvest in _Aut tr was -60% compared to the n° in _Spr tr (as an average over 3 cultivars, table 1)

• the crop reacted by increasing branches (↑ n° capitula/plant) and plant biomass and height

• _Aut tr. reached the maturity 10-days earlier and showed higher achenes yield (+30%, as an overall average) than the _Spr tr. (Table 1)

• safflower oil performed better than sunflower in overall environmental impact although the distribution of the impacts in the four categories was not equal between the two crops (Figure 1)

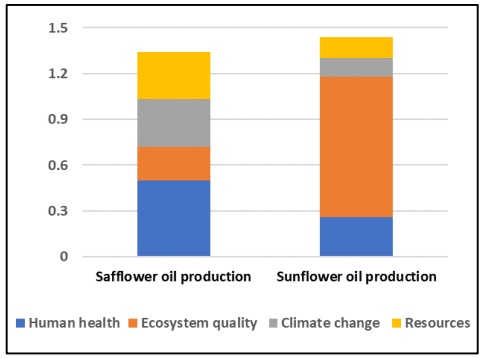

Figure 1: Safflower- Sunflower oil production comparison based on end-point method Impact 2002+ V2.15/Single point.

• safflower oil production had good score for "Ecosystem quality" (i.e., land use, eutrophication, ecotoxicity,…), while sunflower oil production was better for human health, climate change and resources categories

• the highest point for Human health in safflower was mainly due to the need to spraying for pests and diseases control

• the use of the cake for feed generates an environmental advantage for various damage categories as generates an avoided impact especially in the Ecosystem quality category

Conclusions

The autumn sowing resulted a sustainable agricultural strategy able to better taking advantage of water supply in the soil while reaching higher yield compared to spring sowing, especially in two of the three genotypes tested. Moreover, considering the overall lower impact vs other similar crops, the cultivation of safflower is a valid option, especially for marginal land.

Literature: Patanè et. al., 2020. *Ind Crops Prod*, 148, 112313; Koutroubas et al., 2009. *Field Crops Res.*, 112(2-3), 199-204; Jolliet et al., 2003. *Int J Life Cycle Assess*, 8, 324.