SOWING DATES EFFECT ON CAMELINA GROWTH IN DIFFERENT EU CLIMATIC ZONES

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ABSTRACT:Camelina sativa (L.) Crantz, is an annual plant belonging to the Brassicaceae family, as rapeseed. It is native to central Europe where it was widely cultivated until the 1940s. However, only recently it gained the interest of the energy and bio-based industries as a low-cost non-food crop for aviation biofuel production and the oleochemical industry, due to its high oil content (up to 40%) and suitable oil profile. Field trials are performed at different locations in Europe, to study the effect of sowing dates on camelina seed and oil yields, in three different environments, the South (Greece) and North Mediterranean (Italy) climatic zones as well as the Continental zone (Poland). The activity was organized in two separate experiments: autumn sowing and spring sowing with two camelina varieties: Midas, a spring variety supplied by Linnaeus Plant Science (Canada), and Luna, a commercial winter variety from Poland. Total biomass ranged between 2.8 – 9.8 Mg DM ha^{-1}, depending on the site and sowing seasons, with the highest figures in Italy and the lowest in Greece. Seed yields ranged from 0.56 – 2.11 Mg DM ha^{-1}, depending on the site and sowing seasons, with the highest figures in the mild Mediterranean environments. Likewise, oil content ranged between 36.50 – 40.55%. Winter camelina reached almost double the seed yield compared to the spring crop for the same spring variety, Midas. Autumn sowing was found more productive than spring sowing for seed yields and oil content both in Greece and Italy, while in Poland, only real winter camelina varieties survive winter.
Keywords: camelina, sowing dates, seed yields, oil yields, biomass yields

1 INTRODUCTION

The European oleochemical industry currently relies on imported coconut and palm kernel oils and derived fatty acids (FA), and castor oil as sources for medium-chain FA (MCFA, C10–C14) and medium-chain polymer building blocks. These are used for the production of plastics, surfactants, detergents, lubricants, plasticisers and other products. On the other hand, advanced biofuels produced from non-food crops, among other feedstocks, area major challenge for the years to come. The possibility to steadily introduce in Europe the cultivation of new oilseed crops, in order to reduce the dependence from importations, is strategic for the biobased economy, both from the economic but also environmental points of view. The on-going EU-funded project 'COSMOS - Camelina & crambe Oil crops as Sources for Medium-chain Oils for Specialty oleochemicals' addresses this demand by turning two underutilized crops, camelina and crambe, into profitable, sustainable, multipurposeEuropean oil crops for the production of oleochemicals.

Camelina is being studied during the last three years (2015-2017) by the on-going EU-funded project 'COSMOS - Camelina & crambe Oil crops as Sources for Medium-chain Oils for Specialty oleochemicals', along with crambe, for the production of several biobased products. Field trials are performed at different locations in Europe to assess the effect of cultivation practices on seed yields, seed oil content and seed oil profile.

The reasons for selecting this cropare:

- Oil profile: The oils of these crops contain significant amounts of monounsaturated FA with their double bond in an unusual position, fitted for chemical conversion to the typical C12 and C14 coconut and palm kernel FA lauric and myristic acid.

- It is a non-food crop, thus not in competition with the food market

- Can be grown in arid conditions, thus it is not in competition with food crops over good quality agricultural lands and water

Can be grown in rotation with food crops, that can ensure their smooth introduction into the existing cropping systems, internal nutrient recycling and limitations of pests and diseases, avoidance of mono-cultures, better management of the land, agricultural inputs, infrastructure and human resources.

2 METHODS AND MATERIALS

In this work, field trials were established by CRES (Greece), UNIBO (Italy) and UWM (Poland) to study the effect of sowing dates on camelina seed and oil yields, in three different environments. Greece (Aliartos) represents the SouthMediterranean environmental zone as defined by Metzger et al. (2005), Italy (Bologna) the North Mediterranean zone, while Poland (Olsztyn) represents the Continental environmental zone (Fig 1). The countries in which the trials were carried out representalmost half of European Environmental Zones and this is an important issuein drawing conclusions that can be applicable toa wide European territory.

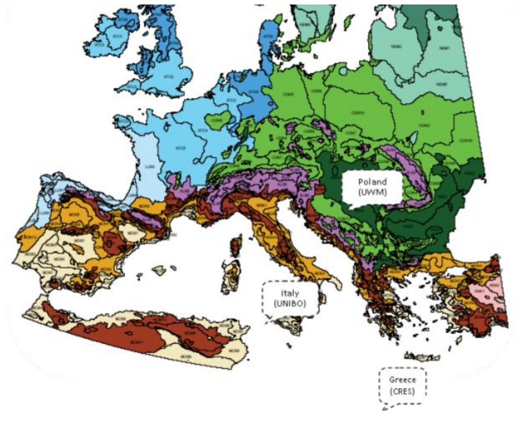

Figure 1: Environmental zones(Metzger et al. (2005)

Details for the sites of the trials, soil types and main climatic characteristics (20-yr historical data) are presented in Table I.

Table I: Locations, soil type and main climatic characteristics (20-yr historical data) of the study sites

Location (Country)	Coordi-nates	Soil type	Mean annual rainfall (mm)	Mean annual temp (°C)
Aliartos (Greece)	38°22'N, 23°6'E	Sandy loam	485	16.7
Bologna (Italy)	44°33'N, 11°23'E	Silty clay loam	613	13.4
Kętrzyn (Poland)	53°51'N, 21°18'E	Sandy loam	683	8.0

The activity was organized in two separate experiments: autumn sowing and spring sowing trials with 2-4 sowing dates, as shown in Table II. Two camelina varieties were tested: Midas, a spring variety supplied by Linnaeus Plant Science (Canada), and Luna, a commercial winter variety from Poland. In the autumn sowings both varieties were tested, while in spring sowings it was only Midas.

Table II: Sowing seasons and times

Winter sowing	Spring sowing
Sowing times: Greece: S1=16.10.15, S2=08.11.15, S3=27.11.15	Greece: S1=04.03.16, S2=21.03.16, S3= 05.04.16
Italy: S1=09.10.15, S2=26.10.15	Italy: S1=12.02.16, S2=15.03.16, S3=30.03/16, S4=12.04.16
Poland: S1=21.09.15, S2= 20.10.15	Poland: S1=05.04.16, S2=15.04.16, S3=25.04.16, S4= 05.05.16
Varieties: Luna and Midas	Midas

In this work, only the earliest and latest sowing time in each season were studied and compared.

The experimental design was a randomized complete block with 3-4 replications, and a similar plot size of 9 m^2 (1.5x6 m^2) was chosen for all the locations. The main phenological stages were surveyed during the crop cycle and total biomass, seed and oil contentwere assessedat harvest.

3 RESULTS AND DISCUSSION

The reported results are from the trials of the first year (Photo 1).

The site and the interaction of the site and seasons significantly influenced seed yield and oil content of camelina(Fig. 2).Highest seed yields were recorded in Italy 1.69 vs 1.37 in Poland and 1.18 Mg DM ha^{-1} in Greece at P≤0.05. Autumn sowings gave higher seed yields compared to spring ones, 1.49 vs 1.35Mg DM ha^{-1}respectively at P≤0.05.

Likewise, oil content was higher in Italy 40.01 vs 38.6 in Poland vs 36.7% in Greece respectivelyat P≤0.05.Autumn sowings also resulted in higher oil content compared to spring ones, 39.2 vs 38.4% respectively at P≤0.05.

Looking deeper into the performance of camelina in each site specifically, in Italy it was the sowing season that affected total biomass and seed yields, whileoil content was also affected by the sowing times and the interaction of seasons and sowings.

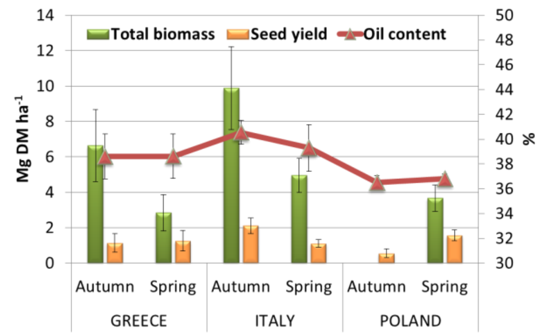

Figure 2: Total biomass and seed yields, and oil content for autumn and spring sowings in three locations.

Autumn sowings were significantly more productive than the spring ones in all studied parameters. Biomass yields for autumn sowings were 9.89 vs 4.96Mg DM ha^{-1} for the spring ones, seed yields 2.11 vs 1.21 Mg DM ha^{-1} and oil content 40.5 vs 38.1% respectively at P≤0.05(Fig. 3).Early or delayed sowings within each season did not affect significantly the yields (biomass and seed), whereas oil content was significantly higher in the early autumn sowing date.

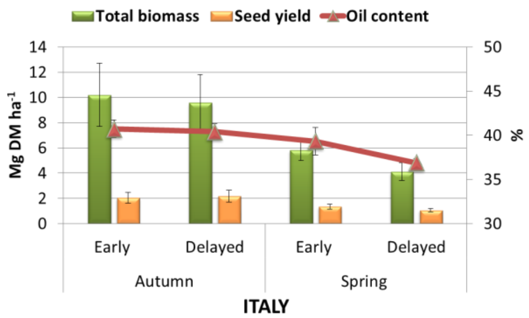

Figure 3: Total biomass, seed yields and oil content for early and delayed autumn and spring sowings in Italy

In Poland, as in the case of Italy, it was only the sowing season that affected significantly seed yields, but in contrast to Italy spring sowings were significantly more productive than the autumn ones (1,55 vs 0,55 Mg DM ha^{-1} respectively, P≤0.05). Again,sowing camelina early or late in the season, both for autumn or spring sowings, had not any statistically significant effect (1.32 vs 1.12 Mg DM ha^{-1}) (Fig. 4).

Oil content was 36.5 and was not affected by any of the studied factors.

In this environment, only real winter camelina varieties, like Luna, can survive the winter. The spring camelina variety Midas sown in autumn did not survive, therefore the yields of the autumn season refer to Luna only and the spring ones to Midas.

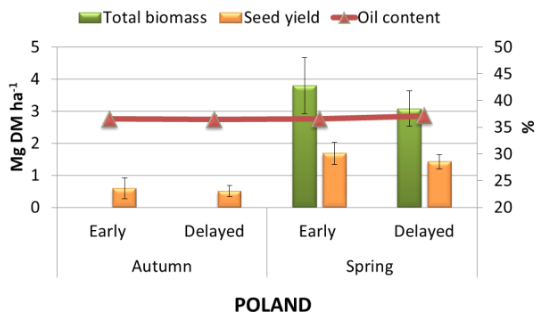

Figure 4: Total biomass, seed yields and oil content for early and delayed autumn and spring sowings in Poland

In Greece, the sowingseasons, times and the interaction of seasons and sowing times affected the total biomass yields.Delayed autumn sowings were significantly more productive than the rest, reaching6.99Mg DM ha^{-1} (P≤0.05). The lowest yields were recorded in the delayed spring sowing with 1.66 Mg DM ha^{-1} (Fig. 5).

Likewise, seed yields were affected by the sowing seasons and their interaction with sowing times. The highest yields were achieved in the delayed autumn and early spring sowings (1.25 and 1.56 Mg DM ha^{-1} respectively), vs 0.7 Mg DM ha^{-1} for the rest (P≤0.05).

Oil content was affected by the sowing times and their interaction with seasons, being significantly higher in the delayed autumn and early spring sowing date (40.1 and 40.6% vs 37.61 and 37.87 % for the rest, at P≤0.05).

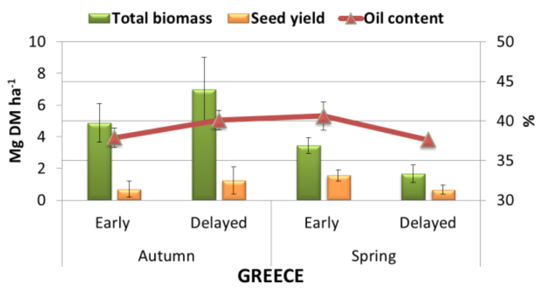

Figure 5: Total biomass, seed yields and oil content for early and delayed autumn and spring sowings in Greece

Comparing autumn vs spring sowing in Italy and Greece, with only Midas variety, site and season affected significantly the biomass and seed yields, and the oil content. Camelina proved to be higher yielding as a winter crop in both sites(Fig. 6). The highest biomass yields were recorded in Italy with 7.26 vs 4.8 Mg DM ha^{-1}in Greece (P≤0.05) and in the autumn sowings (8.63 vs 4.05 Mg DM ha^{-1} respectively).

Likewise, seed yields were significantly higher in Italy (1.54 vs 1.28 Mg DM ha^{-1}at P≤0.05)and in the autumn sowings (1.71 vs 1.18 Mg DM ha^{-1}at P≤0.05). Oil content followed the same pattern, being significantly higher in Italy (39.8 vs 38.9 %) and in the autumn sowings (39.8 vs 39.01% at P≤0.05).

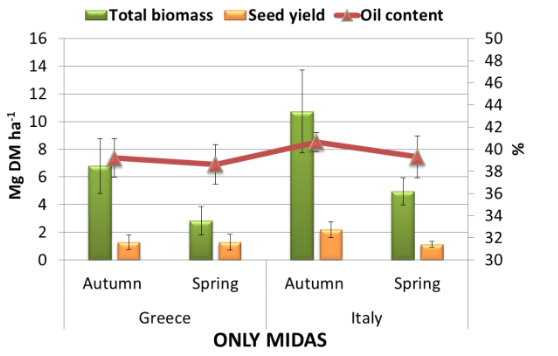

Figure 6: Total biomass, seed yields and oil content for early and delayed autumn and spring sowings in Italy

Photo 1: View of the field trial

4 CONCLUSIONS

Total biomass ranged between 2.8 – 9.8 Mg DM ha^{-1}, depending on the site and sowing seasons, with the highest figures in Italy and the lowest in Greece.

Seed yields followed the same trend and ranged from 0.56 – 2.11 Mg DM ha^{-1}, depending on the site and sowing seasons.

Likewise, oil content ranged between 36.50 – 40.55%, with the highest figures in the mild Mediterranean environments

Winter camelina reached almost double the seed yield compared to the spring crop for the same spring variety, Midas.

Autumn sowing was found more productive than spring sowing for seed yields and oil content.

In Poland, only real winter camelina varieties survive winter.

5 ACKNOWLEDGMENTS

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6 REFERENCES

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