CORE Organic Cofund

"***SCOOP: Developing intercropping systems with camelina to increase the yield and quality parameters of local underutilized crops***"

Deliverable report

D2.2. Report on SCOOP intercropping trials

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Abstract

SCOOP intercropping trials have been carried in four countries (Italy, Poland, Turkey and Bulgaria) across two to three growing seasons, either in autumn and spring sowing, according to specific local needs. Camelina has been grown with different underutilized crops, such as pulses, spices, and minor cereals, as identified within the interaction with local farmers carried out in WP1, living lab activities. In particular, in Italy camelina has been grown with pea, lentil, chickpea, naked oat; in Poland camelina has been grown with flax, pea, red lentil and spelt; in Turkey camelina has been grown with fenugreek, coriander and buckwheat; and in Bulgaria camelina has been grown with pea and vetch. All trials have been carried out in certified organic fields, and arranged in small plots adopting a randomized experimental design. The presented results are the first available for camelina intercropping systems with underutilized crops across different locations and obtained in multi-year field trials. Camelina and companion crops were able to provide satisfactory yield and the intercropping systems provided more stable yields across locations and years, compared to the respective sole-crop, confirming the great potential for these types of cropping systems under organic farming.

1. Introduction

Intercropping systems represent an interesting solution for organic agriculture, since they are able to maximize the ecosystem services while providing diversified productions to the farmers, and thus reducing failure risks linked to the negative impact of climate change. Camelina and underutilized crops represent a good combination of crops, particularly when legume crops are included in the mix. Obviously, a thorough tailoring of the agricultural management of each combination needed to be carried locally, taking into account the specific needs in term of weather and soil conditions, available equipment and acceptance by farmers. SCOOP intercropping trials represent the first attempt of growing camelina and many different underutilized crops, across Europe. In particular, in four European countries, twelve different combinations of crops have been tested across two to three growing seasons, planted either in autumn and in spring. The complete report by country on the obtained data are presented and discussed below.

2. Results for the intercropping trials in Italy (UNIBO)

Introduction

UNIBO performed different trials at the University of Bologna organic experimental farm, located in Ozzano dell'Emilia (44°27′N 11°29′E) along the whole duration of SCOOP project. In particular different combinations and sowing periods (autumn and spring) were tested in order to evaluate which was the most suitable combination for the specific local conditions. All the intercropping systems were based on camelina (*Camelina sativa* L.) combined with different companion crops, mainly pulses, but also naked oat (*Avena nuda* L.) was tested in the last two years of the project.

Experimental protocol of the intercropping trials

The experimental site is characterized by a clay loam soil (34% sand, 37% clay, and 29% loam), with average N and P content, as reported in Table 1. According to the Koppen–Geiger classification, the climate in Ozzano is a typical Mediterranean with the highest and lowest temperatures in July and December, respectively, and the rainy periods concentrated in spring and fall.

Table 1. Main soil physical/chemical properties of the experimental fields at the Ozzano dell'Emilia (Bologna, Italy) experimental station of UNIBO.

Location	Texture	pH	Organic C [g/kg]	N tot [g/kg]	Available nutrients [mg/ kg of soil]	
					P	K
Ozzano dell'Emilia	Clay loam	7.75	13.44	1.41	101	454

All the trials were performed along the duration of the SCOOP project, from autumn 2022 until the end of summer 2024. The camelina variety Cypress (supplied by Smart Earth Camelina, Canada) was grown together with: i) pea (*Pisum sativum* L.), variety Navarro (supplied by Società Italiana Sementi, Italy), ii) lentil (*Lens culinaria* L.), variety Itaca (supplied by Produttori Sementi Bologna, Italy); iii) chickpea (*Cicer arietinum* L.), variety Sultano, (supplied by Produttori Sementi Bologna, Italy); iv) naked oat (*Avena nuda* L.), variety Oliver, (supplied by Padana Sementi, Italy). Camelina and pea, and camelina and chickpea intercroppings were sown in autumn, while all the other combinations were sown in spring (Table 2). Table 2 reports also the main weather data characterizing all the trials.

Table 2. Main dates and meteorological data for the intercropping trials conducted at UNIBO.

Years	Sowing Date	Harvest Date	Growing Cycle Lenght	Tmax °C	Tmin °C	Precipitation mm
			Winter Trials			
Camelina+Pea						
2021/2022	26/10/2021	14/06/2022	231	16.1	5.6	232
2022/2023	27/10/2022	08/06/2022	224	15.4	6.2	558
2023/2024	13/11/2023	19/06/2024	219	16.9	7.0	461
Camelina+Chickpea						
2022/2023	27/10/2022	25/07/2023	271	18.5	8.6	607
2023/2024	13/11/2023	17/07/2024	247	18.8	8.7	587
			Spring Trials			
Camelina+Lentil						
2021/2022	25/02/2022	04/07/2022	129	23.0	10.6	151
2022/2023	09/03/2023	29/06/2023	112	21.4	10.9	317
2023/2024	21/03/2024	17/07/2024	118	23.8	12.9	374
Camelina+Naked Oat						
2022/2023	09/03/2023	05/07/2023	118	22.5	11.7	336
2023/2024	21/03/2024	17/07/2024	118	23.8	12.9	374

Sole-camelina (sown in winter, and in spring), sole-pea, and sole-lentil), sole-chickpea, and sole-naked oat were sown at 8 kg ha^{-1}, 200 kg ha^{-1}, and 160 kg ha^{-1}, 150 kg ha^{-1}, and 150 kg ha^{-1}, respectively. In the intercropping systems, these rates were halved (50:50). Sole-crops were row-seeded, while in the intercropping system, camelina was broadcasted onto the row-seeded pulses. This spatial organization of the experiment was chosen as the most easily acceptable by local organic farmers, interviewed within the living labs organized in WP1. In all trials, the interrow distance was maintained at 0.17 m, regardless of the crops. The sowing depths were 50 mm for pea and chickpea, 30 mm for lentils and naked oat, and 5 mm for camelina. Winter wheat (*Triticum aestivum*) was the preceding crop in 2021/22 and 2022/23 trials, while in the last year the preceding crop was alfalfa (*Medicago sativa*). Prior to sowing, the soil was plowed and harrowed. All the trials were conducted without fertilization. In the first year, emergency irrigation was applied due to prolonged drought following the spring trial sowing, which prevented the establishment of the crops.

Several indexes have been calculated to analyze and compare the different intercropping systems. In particular, LER (Land Equivalent Ratio), Relative Crowding Coefficient, Aggressivity Index, Competitive Ratio, and Crop Performance Ratio (CPR) were analyzed for each of the crop combinations tested.

The following formulas have been used for the calculation of the different indexes.

The **land equivalent ratio** (LER) quantifies the additional land area required for sole cropping to achieve the equivalent agricultural output of an intercropping system. LER suggests that intercropping is more efficient in utilizing ecosystem resources compared with cultivating a sole crop. The LER values were calculated as follows:

LER = LER camelina + LER pulse/cereal

LER camelina = Yic/Ysc

LER pulse = Yip/Ysp

where:

Yic = yield of camelina in the intercropping system.

Ysc = yield of sole-camelina.

Yil = yield of pulse/cereal in the intercropping system.
Ys = yield of the sole pulse/cereal.

The **competitive ratio** (CR) assesses the competitive ability of different species in intercropping systems, specifically focusing on camelina relative to the companion crop. The competitive ratio was calculated as follows:

CR camelina = ((LER camelina)/(LER pulse_cereal) × Z1c/Z2c)

CR pulse = ((LER pulse_cereal)/(LER camelina)× Z2c/Z1c)

Where:

Z1c = sown portion of crops 1.

Z2c = sown portion of crops 2.

Aggressivity (A) is a competitive index, which is a measure of how much the relative yield of one crop component is greater than that of another. Aggressivity is expressed as follows:

A camelina = LER camelina − LER pulse_cereal

A pulse_cereal = LER pulse_cereal − LER camelina

If A camelina or A pulse = 0, both crops are equally competitive. When A camelina is positive then camelina is dominant and when it is negative then pulse is the dominating species.

Another coefficient utilized was the **relative crowding coefficient** (RCC or K), which measures the relative dominance of one species over another within a mixture.

K = K camelina × K pulse_cereal

K camelina =[Y1c/((Y1m-Y1c)) × Z1c/Z2c]

K pulse_cereal =[Y2c/((Y2m-Y2c)) × Z2c/Z1c]

When the product of the two coefficients (K camelina × K pulse_cereal) is greater than 1, there is a yield advantage, when K is equal to 1 there is no yield advantage, and when it is less than 1 there is a disadvantage.

For a two-species intercrop, **Crop Performance Ratio (CPR)**, is expressed as:

CPR= (Y1c + Y2c)/ (Z1c x Y1m) + (Z2c x Y2m)

Where Y1c and Y2c are the yields of the crops 1 and 2 when grown together, Z1c and Z2c are the proportions of crops 1 and 2 in the intercrop, and Y1m and Y2m are the yields of the two crops when grown in monocultures.

Main results

In general autumn sown trials achieved higher seed yields than spring ones (Fig. 1 & 2), and this is very typical in the study environment since usually spring/summer crops highly suffer from prolonged drought and uneven precipitation pattern. Furthermore, in general pea and chickpea are better known crops, for local farmers than lentil and naked oat. Additionally, it is worth highlighting that during May 2023, unconventional precipitation occurred in the site, with about 300 mm of rain concentrated in the first 20 days of May. This caused extensive flooding to all the trials. Taking into account all this, and considering that camelina is an emerging new crop, it is important to remark that a part from the 2022-23 intercropping trial with camelina and naked oat, which failed, due to too high competition of the cereal against camelina, all the other trials were able to provide some seed yields. Obviously, the fine-tuning of all the combination rates and spatial arrangements of the trials was not one of the main focuses of SCOOP, which wanted to follow a learning by doing approach, aiming at optimizing the specific combinations of crops for each sowing date and environment.

The seed yield results of the autumn sown intercroppings are reported in Fig. 1. Interestingly the sole-crops tented to have higher seed yield than in the intercropping, a part for pea which produced significantly higher seed yield when grown with camelina than alone.

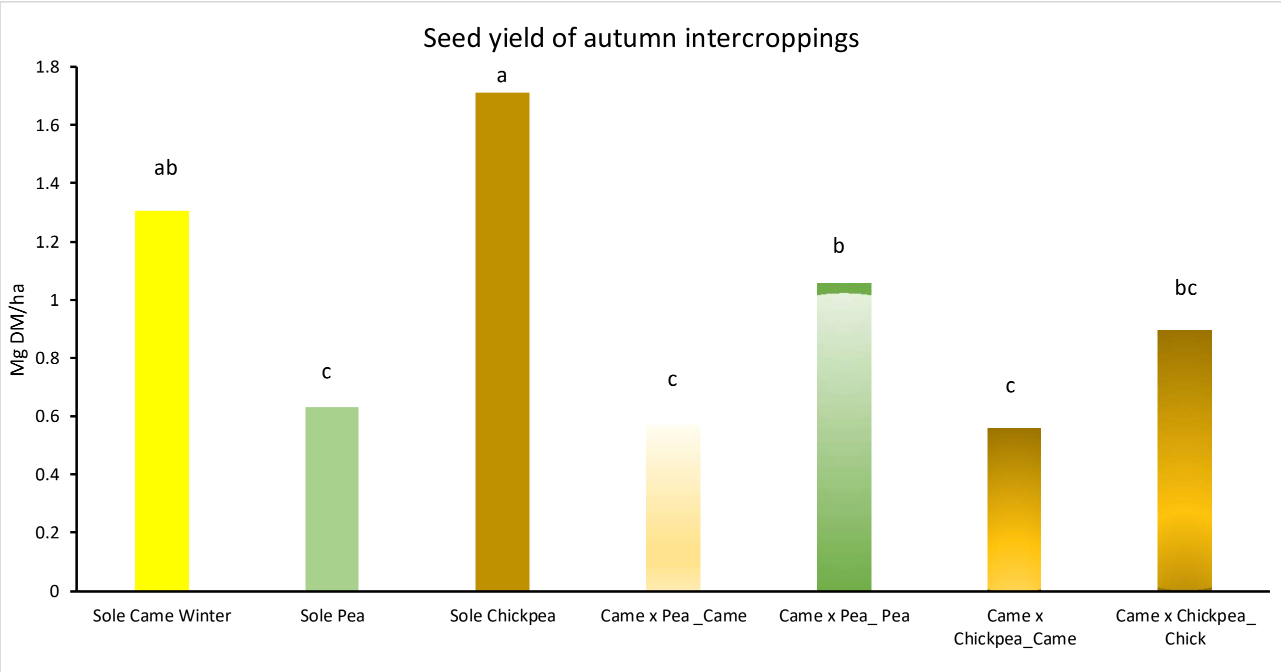

Fig. 1. Seed yield achieved in the different intercropping and sole-crop systems sown in autumn during 2021-24 trials of the SCOOP project at UNIBO. Different letters: statistically significant means for $P \leq 0.05$ (LSD Fisher's test).

Fig. 2. Camelina-Pea intercropping trials, sown in autumn at UNIBO.

Different indexes have been used to analyze the efficiency in using soil of the intercropping systems, as reported in Table 3.

Table 3. Crop indexes calculated in the UNIBO intercropping trials sown in autumn. C= camelina, P= pulse, LER= Land Equivalent Ratio; K= Relative Crowding Coefficient; A= Aggressivity index; CPR = Crop performance ratio.

	LER			K			A		Competitive ratio		CPR
	C	P	C & P	C	P	C & P	C	P	C	P	
Came x Pea	0.44	1.67	2.11	0.78	-2.48	-1.93	-1.24	1.24	0.26	3.83	0.69
Came x Chickpea	0.43	0.52	0.95	0.75	1.10	0.83	-0.09	0.09	0.82	1.22	0.48

Considering the two intercropping systems sown in autumn, the camelina x pea system had the highest LER, mainly in relation to the better performance of pea when grown with camelina than alone. Actually, pea resulted more aggressive and competitive than camelina in this combination, but at the end this seemed the most feasible combination for autumn sowing in northern Italy. The combination camelina x chickpea had a LER almost equal to 1, and in general this intercropping system appeared well balanced between the two crops. Furthermore, when evaluating the revenues for farmers this latter combination might be more profitable since chickpeas have a very high commercial value compared to that of pea (almost 4 times higher).

The results for the spring sown trials are reported in Fig. 3. In spring camelina was grown with lentil (Fig. 4) and also with naked oat. Unfortunately, the data for the first year of this combination are not included in the analysis, since oat had a too high competition against camelina which was not able to produce any seed yield. Seed yield results of the spring crops were significantly lower than those achieved in autumn, and for example camelina when sown in spring had halved yield compared to the autumn sowing (0.60 vs. 1.30 Mg DM/ha, spring vs. autumn sowing of sole-camelina). Additionally, the spring trials had very varying results across years, and this was quite expectable since usually meteorological conditions during spring in the Mediterranean region are very variable alternating periods of prolonged drought, high temperatures, and excessive precipitation. These conditions will probably be even worse in the future due to climate change effects, so probably autumn sown intercroppings might seem the most feasible option to be adopted by farmers.

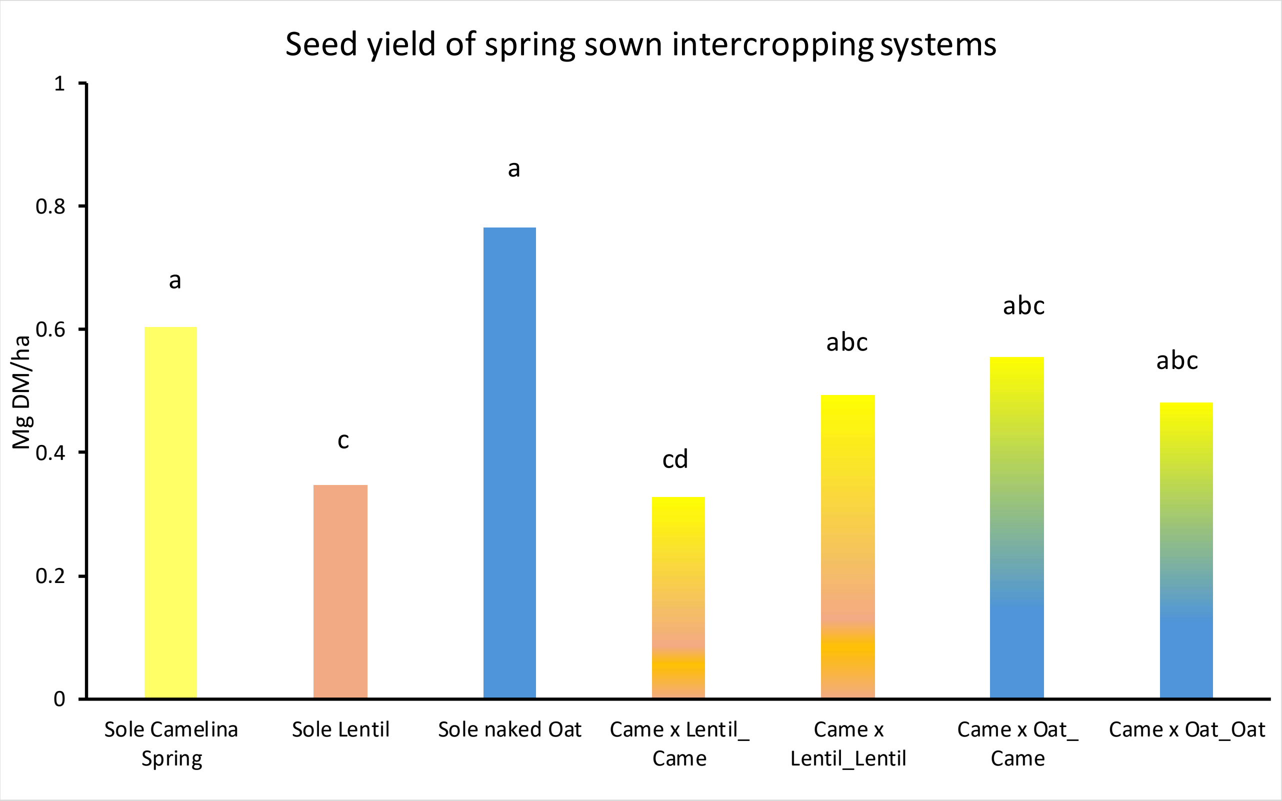

Fig. 3. Seed yield achieved in the different intercropping and sole-crop systems sown in spring during 2022-24 trials of the SCOOP project at UNIBO. Different letters: statistically significant means for *P*≤0.05 (LSD Fisher's test).

Fig. 4. Camelina-Lentil intercropping trials sown in spring at UNIBO, during 2024 growing season.

Different indexes have been used to analyze the efficiency in using soil of the intercropping systems, as reported in Table 4. Both spring intercroppings had LER > 1, and in particular camelina x lentil seemed the best combination in terms of land use. Nevertheless, in this combination camelina appeared very aggressive against lentil.

Table 4. Crop indexes calculated in the UNIBO intercropping trials sown in spring. C= camelina, P= pulse; O= Oat; LER= Land Equivalent Ratio; K= Relative Crowding Coefficient; A= Aggressivity index; CPR = Crop performance ratio.

	LER			K			A		Competitive ratio		CPR
	C	P/O	C & P/O	C	P/O	C & P/O	C	P/O	C	P/O	
Came X Lentil	0.54	1.43	1.97	1.19	-3.35	-2.16	-0.88	0.88	0.38	2.63	0.86
Came X Naked Oat	0.92	0.63	1.55	11.66	1.68	19.61	0.29	-0.29	1.47	0.68	0.91

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3. Results for the intercropping trials in Turkey (CRIFIC)

Soil Physical Parameters and Climate of The Experimental Area of CRIFIC

Field trials were conducted in Ikızce/Haymana Research & Extention and Plant Production Farm, Haymana, located in 39613319N and 32671541E. Ikizce has a semi-arid continental climate with hot, dry summers and cold, snowy winters. The average annual precipitation for the successive three years (2022, 2023 and 2024) was 227.8 mm, the average temperature was 13.7°C, and the humidity was 60.28%.

The experiments were laid out as autumn and spring sowings in the successive three growing seasons between 2021 and 2024. The experimental design was laid out compatible with a randomized complete block design technique, with 4 replicates. The quantity of seed rates was 50:50 in intercropping plots. Plot sizes were 5x5=25 m^2, by 17 cm.

Soil samples were taken from the experimental area, before sowing and after harvest to determine physicochemical parameters (including EC, pH, available phosphorus, available potassium, organic material, lime contents and *Bouyoucos % sand*, clay, silt, and texture analyses). The experimental soil was classified as loam-clay loam. The lime ratio was high (26.99-27.30%), the organic matter was low (0.94-1.43%), the available phosphorus was medium (14.3-30.1 kg/ha) and the pH level was neutral (7.63-7.80).

Seed Material

Camelina (*Camelina sativa*) was the main crop in the intercropping system, and the companions were fenugreek (*Trigonella foenum graecum*), coriander (*Coriandrum sativum*), and in addition that buckwheat (*Fagopyrum esculentum*) in spring sowings. Local varieties were used in the experimental such as; CV Çiftçi (fenugreek), CV Arslanbey (camelina), CV Sancar Bey (coriander), and CV Güneş (buckwheat). The quantity of the seeds were; 25 kg/ha in coriander, 20 kg/ha in fenugreek, 50 kg/ha in buckwheat and 10 kg/ha in camelina. No irrigation or fertilization was applied throughout the three successive growing period.

Results

Autumn Sowings

Autumn sowings were implemented in the middle of November each year. Two successive years research results were assessed (2021 and 2022) while 2023's autumn sowings were damaged from the extreme weather conditions.

Figure 1 shows the yield parameters of autumn plantings of 2022 and 2023 and their averages. The average yield of the sole camelina of the successive two years was 0.74 t/ha. The average yield of the fenugreek was 0.63 t/ha and the coriander sole 0.73 t/ha. Camelina yield as intercropped by fenugreek was 0.54 t/ha and coriander companion as 0,55 t/ha. The average yield of fenugreek as companion was 0.40 t/ha and from coriander companion as 0.36 t/ha.

The successive growing seasons during 2021 and 2022 were assessed for both autumn and spring sowings. However, the autumn sowing of 2023 was excluded from the evaluation due to winter damage. As a result, the yields from the autumn plantings of 2022 and 2023 are shown in the column chart, Figure 5. The average yield of sole camelina over the two years was 0.74

t/ha. The average yield for fenugreek* was 0.63 t/ha, and for sole coriander, it was 0.73 t/ha. The yield of camelina when intercropped with fenugreek was 0.54 t/ha, and with coriander as a companion crop, it was 0.55 t/ha. The average yield of fenugreek as a companion crop was 0.40 t/ha, while coriander as a companion crop yielded 0.36 t/ha.

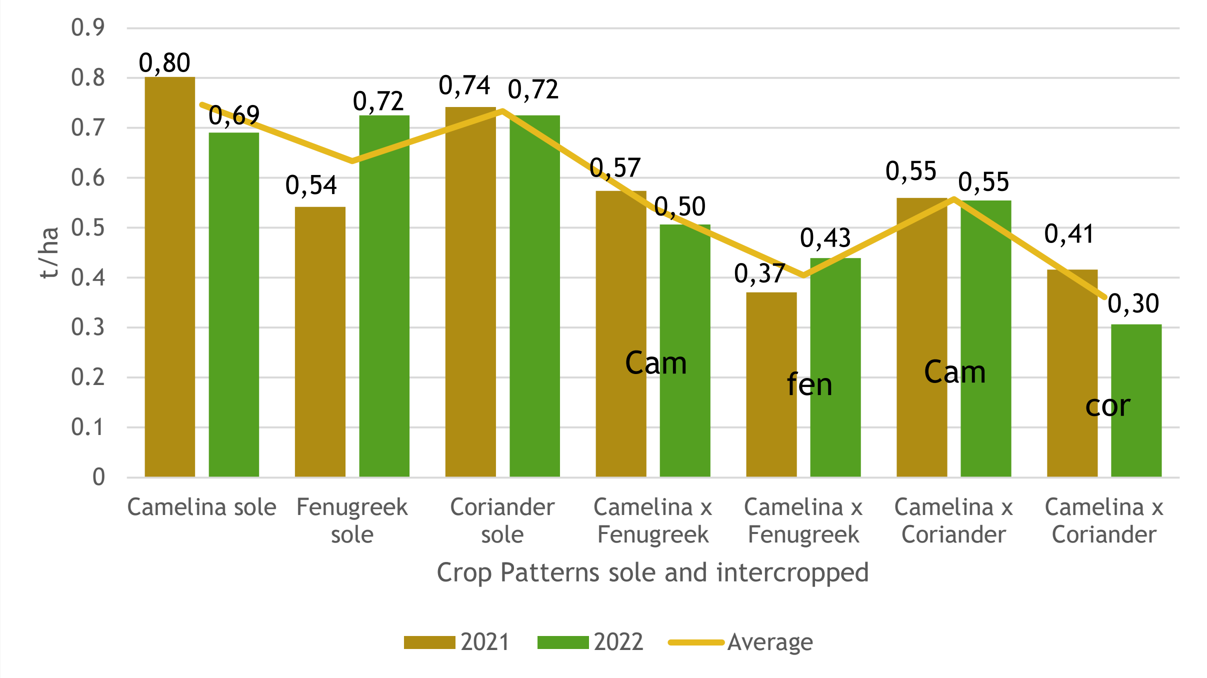

Figure 5. The seed yield amounts (t/ha) of small-scale field trials of Autumn sowings in 2021 and 2022 and their averages obtained in Turkey, at CRIFIC.

The land equivalent ratio (LER) is the relative area of a sole crop required to produce the yield achieved in intercropping. If LER value is equal to one, it means that there is no yield advantage but when LER is more than one, then there is yield advantage. As shown in Table 3 the LER ratio of camelina x fenugreek is 1.33 and camelina x coriander is 1.21; more than 1. So, both combinations have shown yield advantage.

Table 5. Land equivalent ratio (LER), Relative Crowding Coefficient (K), Aggressivity (A), Competitive Ratio (CR), Actual Yield Index (AYL) of the Intercropped patterns of CRIFIC in Autumn sowing in 2022 and 2023

	Land equvalent ratio (LER)			Relative Crowding Coefficient (K)			Aggressivity (A)	Competitive ratio (CR)	Actual Yield Index (AYL)
	Camelina	Medicinal P	Total	Camelina	Medicinal P	Total			
Camelina x Fenugreek	0.73	0.60	1.33**	2.31	1.53	3.84	-0.12	0.82	-0.66
Camelina x Coriander	0.79	0.42	1.21*	3.90	0.73	4.63	-0.37	0.53	-0.78

*0.05%, **0.01%

Aggressivity (A) which is often used to determine the competitive relationship between two crops used in the mixed cropping (Willey, 1979). Also, competitive ratio (CR) is another way to assess competition between different species. The CR gives more desirable competitive ability for the crops and is also advantageous as an index over K and AYL (Dhima et al., 2007). As shown in Table 1, CR value of both combinations has advantageous regarding K and AYL values.

Spring Sowings

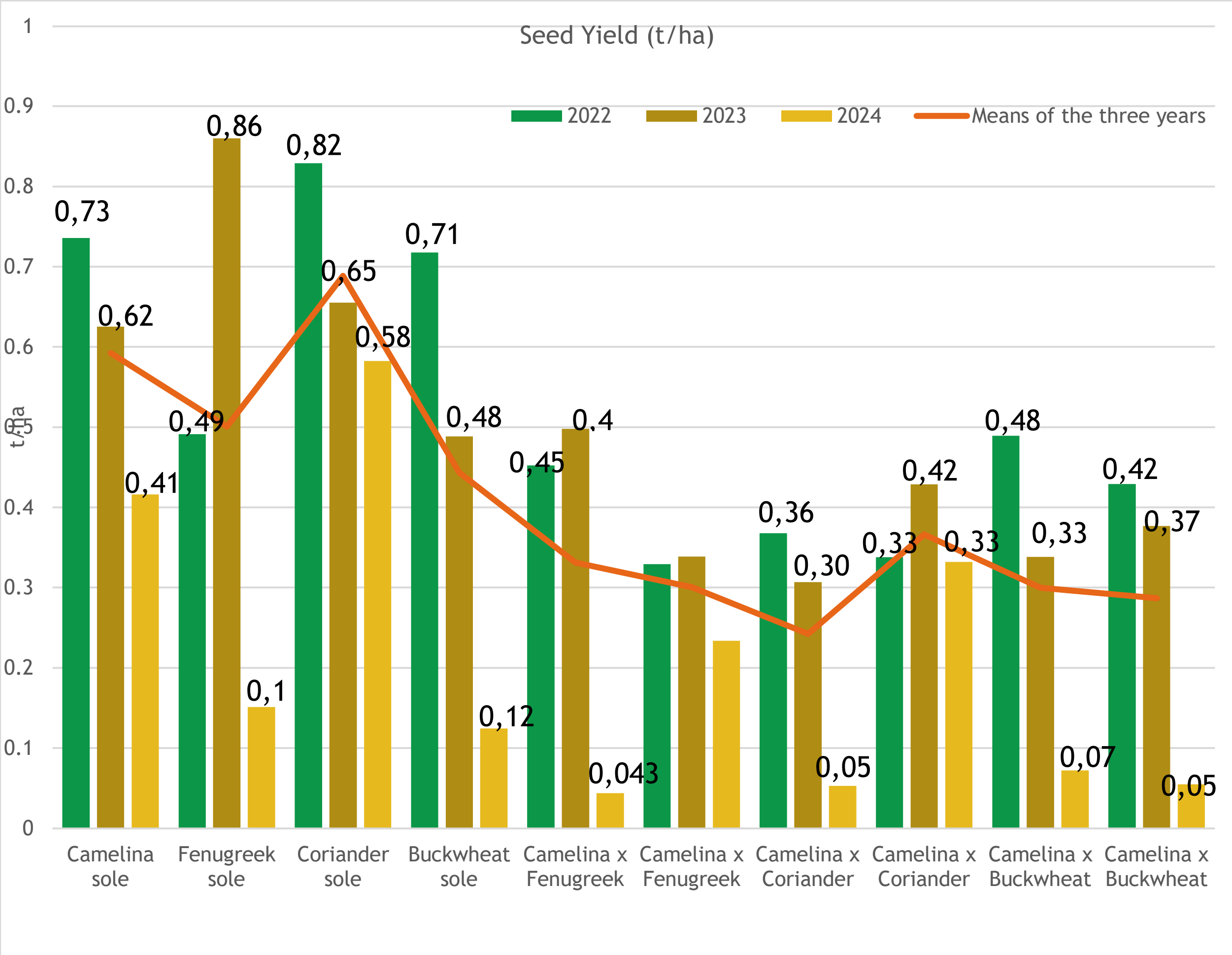

Figure 6. Small-Scale Field Trials of Spring sowings in 2022, 2023, 2024 and their averages obtained in Turkey, at CRIFIC.

Over the consecutive years of 2022, 2023, and 2024, three spring sowings were conducted. However, in 2024, the total rainfall during the entire growing season was only 114 mm, resulting in significantly lower seed yields compared to the previous seasons As presented in Figure 6, the average seed yields for sole crops were as follows: camelina at 0.59 t/ha, fenugreek at 0.50 t/ha, coriander at 0.68 t/ha, and buckwheat at 0.44 t/ha. In comparison, the average yields of intercrops were lower, with fenugreek producing 0.30 t/ha, coriander 0.36 t/ha, and buckwheat 0.28 t/ha.

Table 6. Land equivalent ratio (LER), Relative Crowding Coefficient (K), Aggressivity (A), Competitive Ratio (CR), Actual Yield Index (AYL) of the Intercropped patterns of CRIFIC in Spring sowing in 2022, 2023 and 2024

	Land equivalent ratios (LER)			Relative Crowding Coefficient (K)			Aggressivity (A)	Competitive ratio (CR)	Actual Yield Index (AYL)
	Camelina	Medicinal P	Total	Camelina	Medicinal P	Total			
Camelina x Fenugreeek	0.661	0.507	1.168	1.269	1.030	2.299	-0.154	0.766	-1.149
Camelina x Coriander	0.604	0.531	1.135	0.543	1.135	1.678	0.047	0.879	-1.079
Camelina x Buckwheat	0.598	0.556	1.154	2.089	1.832	3.921	0.048	0.930	-1.083

As indicated in Table 6, the LER ratio for camelina x fenugreek is 1.168, camelina x coriander is 1.135, and camelina x buckwheat is 1.15, all exceeding 1. This demonstrates that all three combinations provided a yield advantage compared to sole cropping systems. Similarly, consistent with autumn sowings, the CR values for each combination also showed advantages in terms of both K and AYL values.

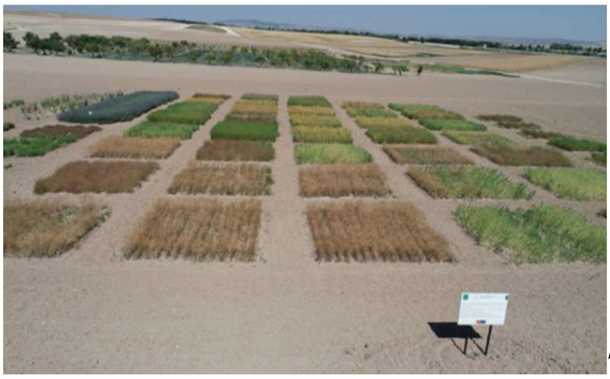

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Figure 7 & 8. Drone images and field trials images of both experiments (autumn and spring sowings) in 2023

4. Results for the intercropping trials in Bulgaria (AUP)

Small scale field trials on camelina intercropping systems in Bulgaria in 2022-2024

The trials in small plots were conducted in the certified organic field of the Agroecological centre of AUP for 3 successive years – from 2022 to 2024. Plovdiv is located at Central Bulgaria, Thracian valley (N: 42° 08' 60.00" E:24° 44' 59.99") (Fig. 9). Evaluation of the productive potential and environmental impact of sole and intercropping systems of camelina has been made along with optimizing the crop technology for the local conditions and equipment.

Figure 9. Location and sowing of the small plots field trial in AEC of AUP in 2022.

The experimental field is Aluvial Fluvisols with a physical clay content of 37.05 - 37.9% and was characterized by an average sandy-clay soil texture. The soil reaction was slightly acidic to neutral with a pH of 6.9 – 7.0. The humus content was 2.48 - 2.52%, and the soil was rated as average stocked. Regarding the content of total carbonates, it was found that it was in average values of 4.52 - 4.58% (Table 7).

Table 7. Soil indicators of an average soil sample before sowing and before fertilization from the experimental plot

Year	Depth (cm)	Total Carbonates %	pH /H_2O/	Soil texture (glay) <0,01 mm %	Humus content %
2022	0-20	4.52	6.9	37.05	2.52
2023	0-20	4.58	7.0	37.4	2.50
2024	0-20	4.55	6.9	37.9	2.48

Regarding the values obtained for the agrochemical indicators before fertilization (Table 8), it was found that the soil was poorly stocked with nitrogen (7.0 - 7.42 mg/1000g) and phosphorus (10 - 11.9 mg/100g) and well stocked with potassium (42.9 - 58.80 mg/100g).

Table 8. Agrochemical indicators of an average soil sample before sowing and before fertilization from the experimental plot

Year	Depth (cm)	$N\text{-}NH_4$	$N\text{-}NO_3$	Total mineral nitrogen, mg/1000g	P_2O_5	K_2O
		mg/1000g	mg/1000g		mg/100g	mg/100g
2022	0-20	3.42	4.0	7.42	10.0	58.80
2023	0-20	3.15	3.9	7.05	11.5	42.9
2024	0-20	3.10	3.9	7.0	11.9	44.4

Following the scope of the project and the discussions in the Living Labs (WP1) the experimental design includes 3 different genotypes of camelina (*Camelina sativa*) - 2 introduced varieties – K1 Luna and K2 Lenka and one local landrace K3 BG, and Bulgarian varieties of forage pea (*Pisum sativum*) – Mir and vetch (*Vicia sativa*) Obr. 666.

The spring sowing - 24/02/2022 on 12,5 cm interrow distance was with 10 kg ha^{-1} for camelina, 200 kg ha^{-1} for pea and 180 kg ha^{-1} for vetch (Tab. 9). Pea and vetch were sown at 4 cm, and camelina on 1-2 cm depth. Intercropping of each camelina variety with pea and vetch was set with reduction of camelina seeds by half and for the companion crop – by a third.

No chemical plant protection products or irrigation were provided during the cultivation. Preceding crop was typical for local organic farms' winter rye. A randomized complete block design was used as each variant of sole and intercrop was in 3 replicates of small plot of 10.78 m^2 (7.7 m x 1.4m). The poor field germination of camelina was due to the soil cultivation and the small size of the seeds. The next sowings were made at a smaller depth of 1 cm with rolling of the soil before and after camelina.

Table 9. Sowing rate and plant emergence in sole and intercropping camelina and pea/vetch

Variants	Sowing rate, g.s. per m^2	Number of plants per m^2	Germination rate, %	Plants in intercropping per m^2, %	
				came	pea/vetch
K1 Luna	1000	316	32	100	-
K2 Lenka	1000	372	37	100	-
K3 BG	1000	389	39	100	-
Pea	142	69	49	-	100
Vetch	155	105	68	-	100
K1 / P	500+83	196	34	81.1	18.9
K2 / P	500+83	138.7	24	78.4	21.6
K3 / P	500+83	343.5	59	91.3	8.7
K1 /V	500+111	142	23	61.3	38.7
K2 /V	500+111	170	28	65.9	34.1
K3 /V	500+111	273.3	45	74.4	25.6

Preliminary field trial was set according to the LL requirements to establish the best nitrogen nutrition regime for camelina vegetation and productivity. Results showed as optimal level of 30 kg N/ha and no significant increase in the yield when applied double dose (Fig. 10). In the next years for small- and large-scale trials mineral nutrition was applied to ensure three kilograms of active substance nitrogen with certified organic farming fertilizer Bioazoto 12.

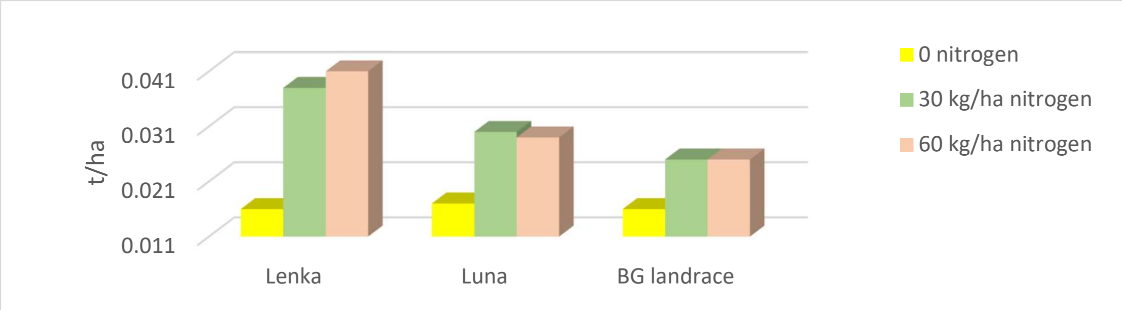
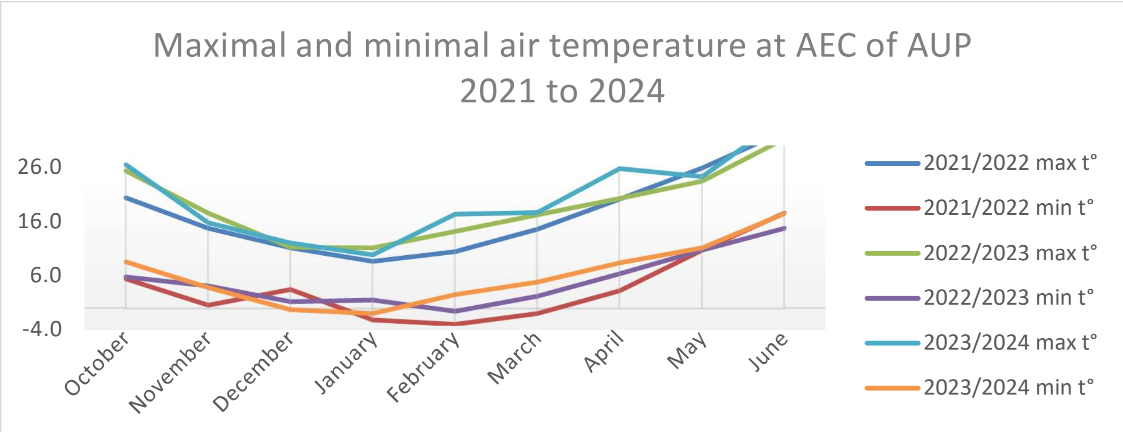


Figure 10. Seed yields of camelina with different N fertilization, t/ha

The meteorological conditions (Fig. 11A, B) during the experimental period were favorable for the development of the crops. The good tolerance to low temperatures of camelina and pea permitted autumn and spring sowing but even for the vetch the mild winter was not a problem. Late frosts in April caused anthocyanin leaf coloration and slowed down the vegetation but no frost injuries were observed during the experiment.



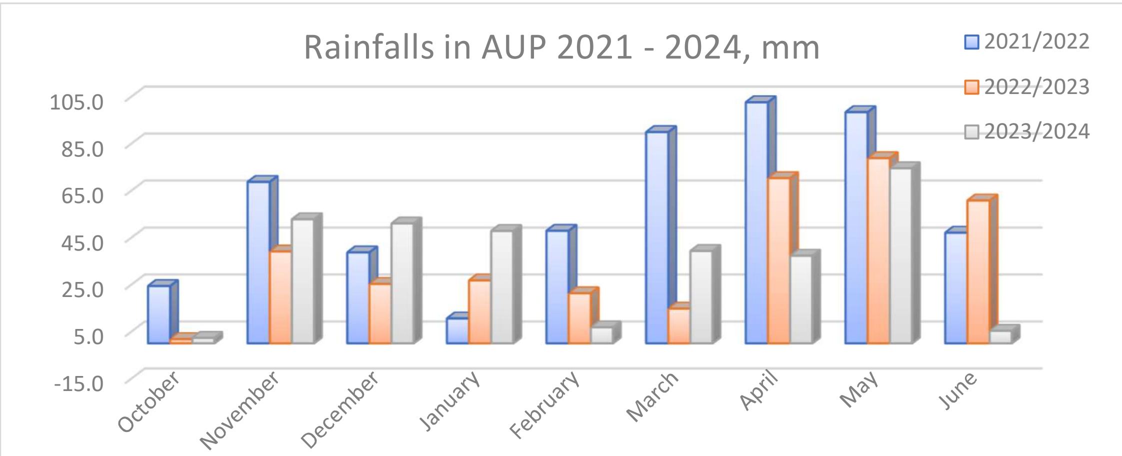


Figure 11A and B. Weather conditions during the vegetation period of camelina – spring and winter for the experimental period from 2021 to 2024.

The limiting factor was the soil humidity as the rainfall is irregular (Fig. 11B). The germination in the second and the last year were late in autumn due to the prolonged drought. Another problem is the precipitation in the late vegetative stages which provokes additional development of lateral branching of camelina and growth of late weeds and postponed the harvest in the first two years. This is also related to pod shattering and losses of yield in pea and partially in vetch. In camelina plants such a problem was not observed. Lodging plants in sole crop of pea additionally hardened the mechanical harvest. Manually plants were collected only for biometrical analyses. Serious losses of camelina seeds were observed during harvest with plot combine. Cleaning of seeds from green impurities and insects and separation of both crops from mixed population should be done as soon as possible to keep the quality of the production.

Figure 12. Small trials of camelina in sole crop and intercropped with pea and vetch on certified organic field of AEC – AUP 2022 – 2024.

Cultivation of different varieties of camelina became a requirement of farmers during the Living Labs. The aim is to identify their differences and potential for productivity and adaptability in our conditions, as there is no registered variety in Bulgaria. The introduced Polish varieties Luna and Lenka has good cold and drought tolerance and were compared to a local landrace, unregistered yet. There was a clear variation in vegetation and growth of the genotypes. Faster initial development of Lenka is observed in autumn plots. Earlier sowing is typical for the northern varieties but here their vegetation is slower in the winter than the local and their plants remain shorter in sole crops (table 10 and 11). Similar are the plots sown in the spring. Mixed Luna and vetch crops are taller than the other plots in both dates of sowing.

Table 10. Plant height of camelina, winter sowing by phenological growth phase, cm

Variants	Plant height of camelina, autumn sowing by phenological growth phase, cm			
	Single true leaf on the third node developed/ BBCH 13	Inflorescence visible from above / BBCH 21	Visible colour button / BBCH 51	Full flowering: 50% of flowers open /BBCH 65
K1 Luna	4	45.5	51.9	56.1
K2 Lenka	3.6	49.3	47.3	53
K3 BG	3.5	40.7	42.6	59
K1 / P	4	49.7	51	58.8
K2 / P	4.1	59.7	60.2	63.4
K3 / P	4	46.6	56.9	65.2
K1 /V	3.6	51.7	55.5	66.6
K2 /V	3.3	48.2	51.8	62.3
K3 /V	3	50.3	51.9	63.9
average	3.7	49.1	52.1	60.9

In autumn sowing the plants are taller compared to the one of spring sowing. Highest are the variant of intercropping with Luna and vetch and BG landrace with pea. The shorter vegetation period in the spring decreases the differences between the variants.

Table 11. Plant height of camelina, spring sowing by phenological growth phase, cm

Variants	Plant height of camelina, spring sowing, by phenological growth phase, cm			
	Single true leaf on the third node developed/ BBCH 13	Inflorescence visible from above / BBCH 21	Visible colour button / BBCH 51	Full flowering: 50% of flowers open /BBCH 65
K1 Luna	3.7	20.7	27	38.4
K2 Lenka	3.3	20.8	27.2	36
K3 BG	3.3	19.7	27.5	40
K1 / P	4	20.6	23.2	35.6
K2 / P	3.3	21.4	29.9	39.3
K3 / P	4	22.2	25	37.2
K1 /V	3.3	22.1	26.1	41.2
K2 /V	3	24.3	27.4	39.3
K3 /V	3.3	20.9	30.2	40.5
average	3.5	21.4	27.1	38.6

On Table 12 is presented the data concerning abundance-dominance observations as Visual assessment as described below by Braun-Blanquet abundance-dominance scale. The scale is described by the following figure:

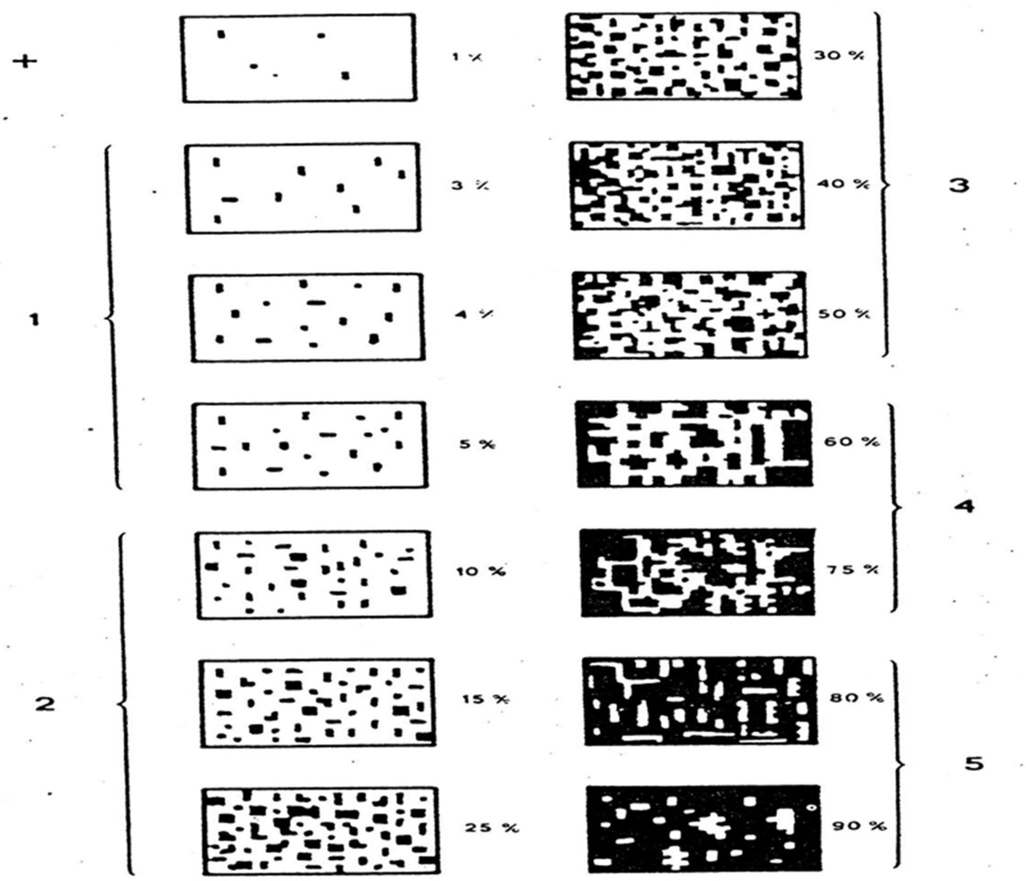


Fig. 2.19 - Modelli per una stima delle percentuali di abbondanza-dominanza secondo il metodo di Braun-Blanquet.

Two assessments were performed in the spring trial – first – in rosette stage and second – in end of flowering stage.

Table 12. Visual assessment by Braun-Blanquet abundance-dominance scale (spring), %

Treatments	2023			
	1st in Rousette stage		2nd End of flowering	
K 1	60	-	90	-
K 2	65	-	90	-
K 3	75	-	95	-
Pea	60	-	80	-
Vetch	60	-	70	-
K 1 / Pea	60	40	80	20
K 2 / Pea	65	35	80	20
K 3 / Pea	65	35	85	15
K 1 / Vetch	70	30	80	20
K 2 / Vetch	70	30	85	15
K 3 / Vetch	75	25	85	15
Treatments	2024			
	1st in Rosette stage		2nd End of flowering	
K 1	50	-	95	-
K 2	55	-	95	-
K 3	70	-	95	-
Pea	55	-	85	-
Vetch	55	-	80	-
K 1 / Pea	65	35	80	20
K 2 / Pea	65	35	85	15
K 3 / Pea	70	30	90	10
K 1 / Vetch	75	25	90	10
K 2 / Vetch	75	25	90	10
K 3 / Vetch	80	20	90	10

In the first observation date the highest percent of area abundance was for the sole crop of the Bulgarian camelina landrace as sole crop and as mixed crop with vetch – 75 and 70% in 2023 and in 2024 respectively. The foreign camelina varieties were with lower abundance as sole crops and as mixed crops with pea and vetch. The pea and vetch had abundance of 55-60% in the different years. Their mixed cropping with the camelina varieties led to abundance varying from 25 to 40% in the different seasons.

On the second evaluation date the abundance-dominance percentage was in favour of the camelina sole crops that varied from 90 to 95% of the sown area. It was found in both experimental years. The pea and vetch reached 70-80%. It was found that the camelina varieties grown as mixed crops developed more vigorously and dominated the area when sown together with pea and vetch. The abundance percentage in the mixed cropping system was in favour of the camelina varieties when compared to the legumes.

AUTUMN TRIALS

The development stages of camelina varieties, pea, and vetch in the experimental plots and area were reported. The observations showed no significant differences regarding the growth stages of the camelina varieties, pea and vetch in the autumn sowings. The abundance of the crops in the experimental area was reported. Three reporting stages were evaluated – 1st - Rosette stage (in autumn), 2nd - butonisation stage, and 3rd - End of flowering.

Table 13. Visual assessment by Braun-Blanquet abundance-dominance scale (autumn), %

Treatments	2023					
	1st - Rosette stage		2nd - butonisation stage		3rd - End of flowering	
K 1	65	-	80	-	95	-
K 2	65	-	80	-	95	-
K 3	80	-	85	-	100	-
Pea	70	-	80	-	95	-
Vetch	70	-	80	-	90	-
K 1 / Pea	65	35	80	20	90	10
K 2 / Pea	65	35	85	15	90	10
K 3 / Pea	70	30	90	10	95	5
K 1 / Vetch	70	30	80	20	90	10
K 2 / Vetch	70	30	90	10	95	5
K 3 / Vetch	80	20	90	10	95	5
Treatments	2024					
	1st - Rosette stage		2nd - butonisation stage		3rd - End of flowering	
K 1	60	-	85	-	90	-
K 2	60	-	85	-	90	-
K 3	75	-	90	-	100	-
Pea	65	-	85	-	95	-
Vetch	65	-	85	-	95	-
K 1 / Pea	65	35	75	25	90	10
K 2 / Pea	65	35	85	15	95	5
K 3 / Pea	75	25	90	10	95	5
K 1 / Vetch	70	30	90	10	90	10
K 2 / Vetch	70	30	90	10	95	5
K 3 / Vetch	75	25	95	5	95	5

In the autumn, the camelina varieties K 1 and K 2 were with lower abundance as sole crops, when compared to the Bulgarian landrace as sole crop. Pea and vetch reached 70% abundance in both years of study. Similar results were obtained for the camelina varieties grown as mixed crops. In autumn, in the different years, when grown as mixed crops with pea, the camelina varieties reached 65-75% abundance, and the rest was the pea – 25-35%. The situation with the vetch was similar. The abundance was in favour of camelina and the legume abandoned 25-35% of the area in the autumn.

In spring, the abundance of the crops on the area was evaluated in butonisatuon stage. It was reported that the camelina varieties as sole and mixed crops with pea and vetch reached abundance from 80 to 95%. As mixed crops the pea and vetch abundance were between 5 and 25% in the different seasons.

In the third reporting of the abundance-dominance percentage of the crops was found that the Bulgarian camelina landrace reached 100% of area abundance as sole crop. It was found in both years. The camelinas K 1 and K 2 were with 90-95% of abundance. As mixed crops the camelina varieties reached abundance between 90 to 95%. The pea and vetch area abundance decreased to 5-10% in the mixed cropping systems.

From the obtained results it can be concluded that in the autumn sowing, the camelina varieties showed greater area abundance when compared to spring sowings.

The total potential for cultivation in organic farming as sole or intercrop is evaluated by grain production, harvested by plot combine. The seeds were cleaned and separated additionally, and quality analyses were made (WP 3).

The local landrace has a bigger productivity of grain in sole and mixed crops in both sowing periods (Fig. 13 and 14). This stable advantage could be a reason for later official testing and registration as variety.

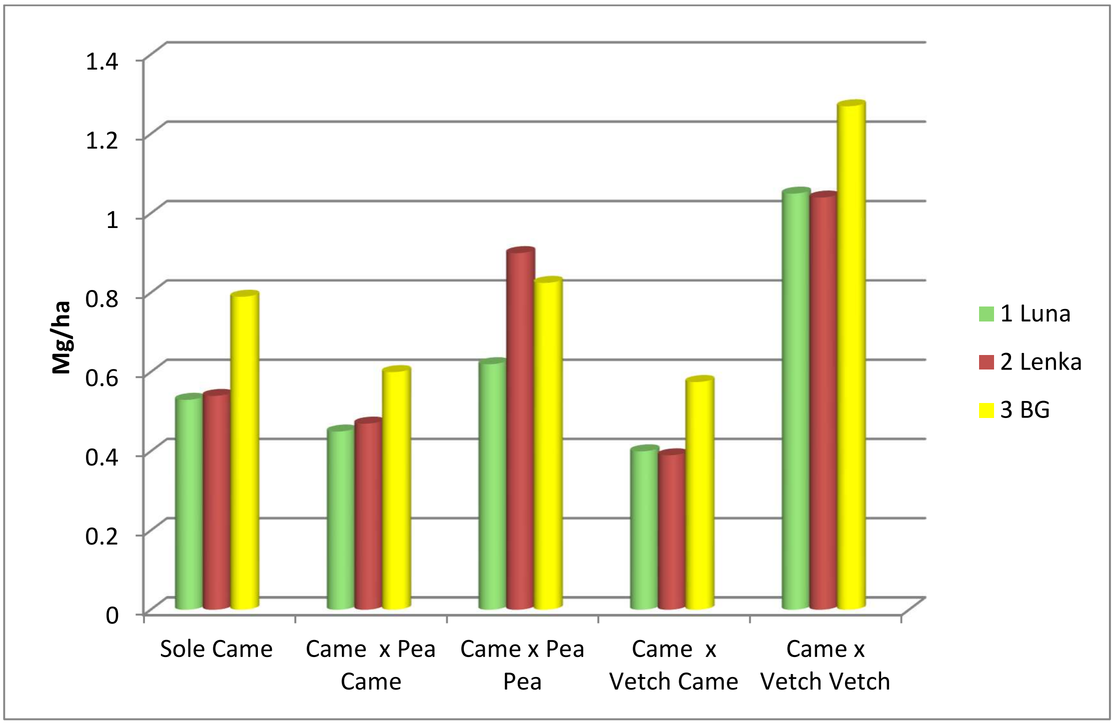


Figure 13. Average yields of 3 genotypes camelina with spring sowing in sole and intercropping system with pea and vetch in organic trials during 2022 to 2024, Mg/ha

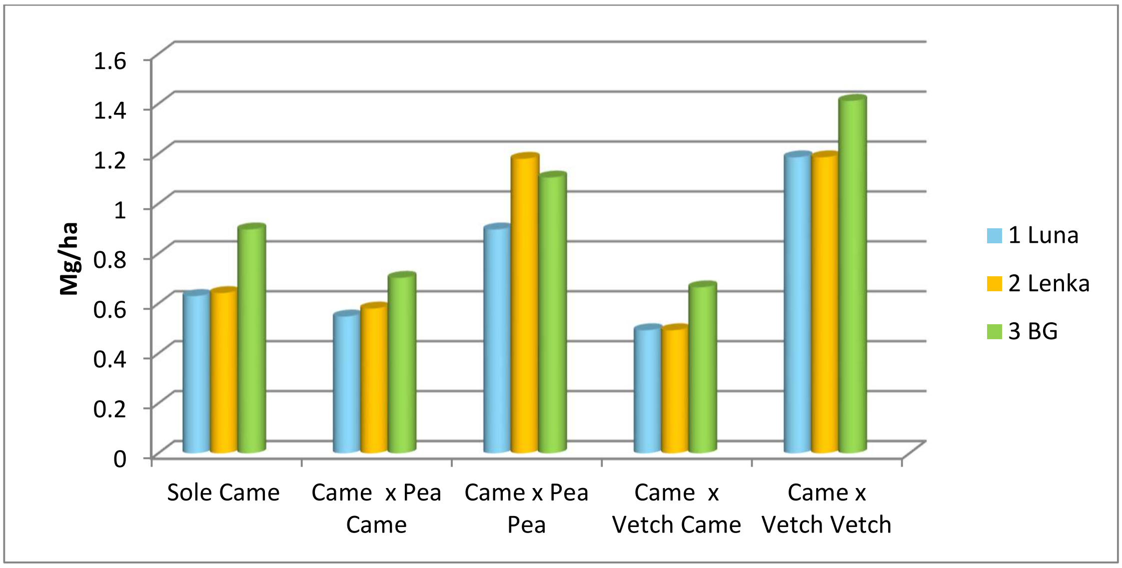


Figure 14. Average yields of 3 genotypes camelina with autumn sowing in sole and intercropping system with pea and vetch in organic trials during 2022 to 2024, Mg/ha

The total production of sole and intercropping systems varies in autumn and spring sowing (Fig. 15). Highest production of obtained from the combination of vetch and the local landrace – 2.077 Mg/ha (autumn sowing) or 1.845 Mg/ha (spring). The average yield of the 3 camelina genotypes and vetch, sown in the autumn reaches 1.807 Mg/ha.

The pure stand of vetch has better productivity in spring sowing. Intercropping of pea even with lower, but still very good yields, is preferred by farmers as the production is well accepted in animal husbandry and has large market. Also they appreciate the good stand of relatively free of weed plots, and lower levels of lodging. Despite this delay of the harvest caused significant losses of grains due to pod shattering. Prolonged rainfalls at full maturity were the major constrain for normal harvesting.

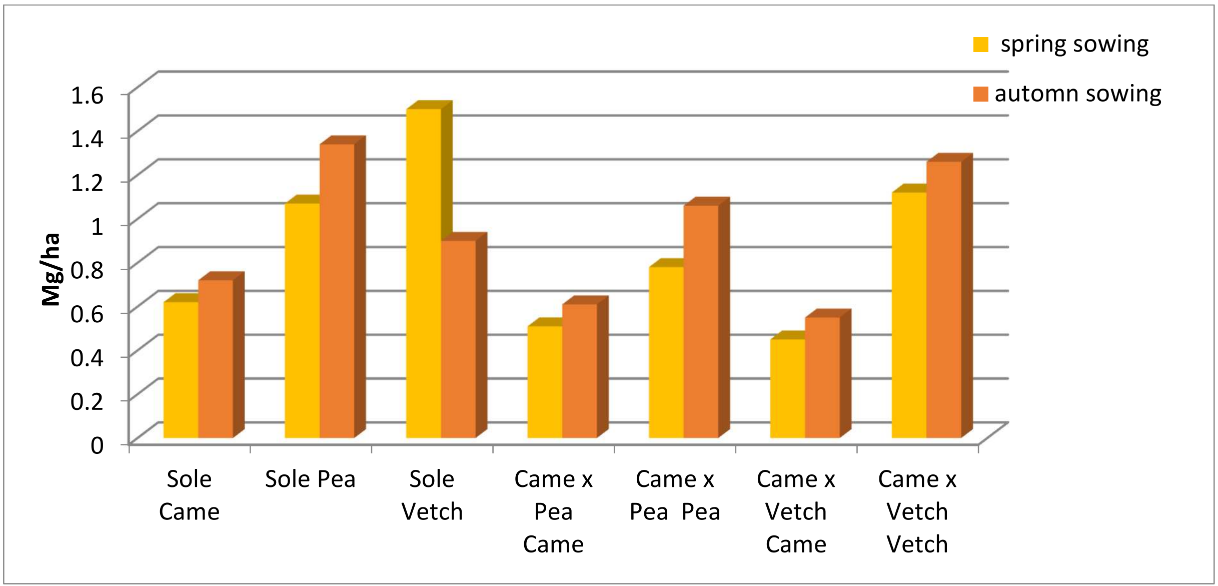


Fig 15. Average yields of camelina, pea and vetch in spring sowing of small plot trials in AEC of AUP 2022 – 2024, Mg/ha

Performance analysis of mixed cropping has been done using several indices (Tab. 14 & 15). The highest LER is obtained for the intercropping of camelina and vetch in winter and camelina and pea in spring sowing. In our trial vetch in winter aggressed more than the other crops

Table 14. Crop indexes calculated in the AUP intercropping trials sown in autumn

Spring sowing	LER			Relative Crowding Coefficient			Aggressivity index		Competitive ratio		Crop performance ratio
	Came	Pulse	C & P	Came	Pulse	C & P	Came	Pulse	Came	Pulse	
came x pea	0.82	0.73	1.55	28.48	0.44	28.92	0.09	-0.09	6.90	0.14	2.57
came x vetch	0.73	0.66	1.38	13.90	0.10	14.00	0.07	-0.07	5.78	0.17	3.29

Table 15. Crop indexes calculated in the AUP intercropping trials sown in spring

Winter sowing	LER			Relative Crowding Coefficient			Aggressivity index		Competitive ratio		Crop performance ratio
	Came	Pulse	C & P	Came	Pulse	C & P	Came	Pulse	Came	Pulse	
came x pea	0.84	0.79	0.79	3.05	0.61	3.66	0.06	-0.06	6.58	0.15	2.87
came x vetch	0.76	1.04	1.80	16.56	-5.18	11.38	-0.28	0.28	3.84	0.26	3.17

5. Results for the intercropping trials in Poland (UWM)

Small-scale field trials were conducted between 2022 and 2024 in Northeastern Poland on an organic farm located in the village of Mierki (N:53°59’31” E:20°32’84”) (Fig. 16). The experiment was established on Eutric Cambisol formed from loamy sand lying on sandy loam.

In 2022, based on the information obtained from living labs (WP 1) and the assumptions of the SCOOP project, camelina and three companion crops – flax (Bukoz variety), red lentil and spelt wheat (Wirtas variety) were selected for the experiments. Crops were sown (April 2022) in quantities: camelina (variety Olivia) 7 kg/ha, and then, respectively for the companion crops: 80 kg/ha, 60 kg/ha and 190 kg/ha. The second factor in this experiment was the type of sowing: sole cropping (each of the four species) and the intercropping, i.e. camelina and companion species. The companion crops were sown in rows, while camelina was broadcasted. Two sowing densities were used in the intercropping systems: 58.3% (variant 1 – high density of the companion crop) and 41.7% (variant 2 – low density of the companion crop) of standard sowing rate for companion crops. Each combination was sown in 4 replicates on 9 m^2 plots. The forecrop for this experiment was a white sweet clover (*Melilotus albus*). No fertilization, chemical plant protection8 and irrigation were used. In 2023 and 2024, the experiment was modified. Instead of flax, which was suppressed while intercropped with camelina, it was decided to sow pea. It was also decided to increase the density of companion crops in the intercropping to 83.3% (variant 1 – high) and 58.3% (variant 2 – low). The plot size and the number of replicates remained unchanged. The experiment was performed in randomized block design.

Fig. 16. Location and establishment of the field trial in 2022

The weather significantly influenced the development of the crops in individual years, where high temperature and precipitation distribution had a significant impact (Fig. 17-20). Growing season of 2022 was characterized by the best weather, although in April the average air temperature was lower than in the multi-year period. These lower temperatures affected the late emergence of lentil but did not affect other species. Precipitation in April was also lower than in the multi-year period, but this did not affect the development of the crops because the soil contained a large accumulation of autumn-winter water. On the other hand, precipitation in May and June was twice as high as in the multi-year period, allowing for proper plant development. Unfortunately, in subsequent years, precipitation in the months of April-June was much lower than in the multi-year period, and its distribution was very unfavourable. For example, in May 2023, only 18.6 mm of rain fell, and in June the first significant rainfall occurred only in the middle of the month. In 2024, 83% of rainfall in May fell only on May 28th-30th. In June they were twice as low as in the previous multi-year period. At the same time, the months of April-June were characterized by high air temperatures, which significantly affected the growth and development of plants.

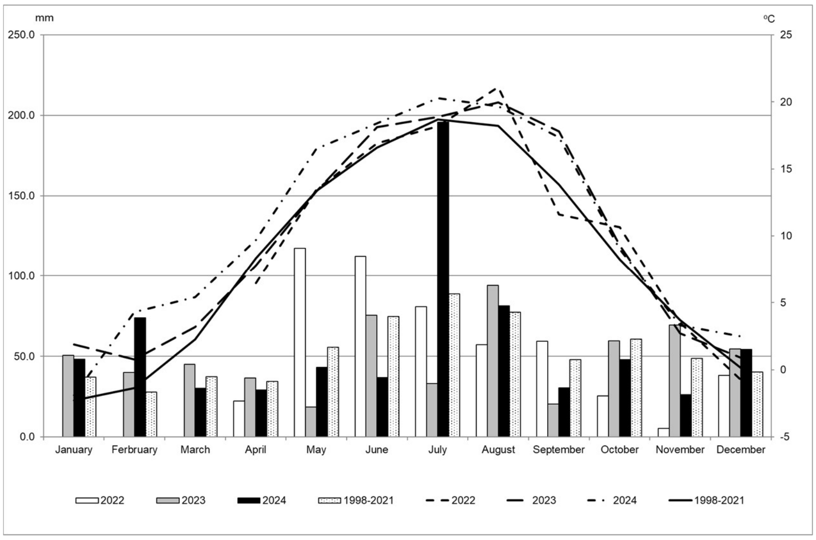


Fig. 17. Meteorological data from Mierki field trials site in years 2022-2024

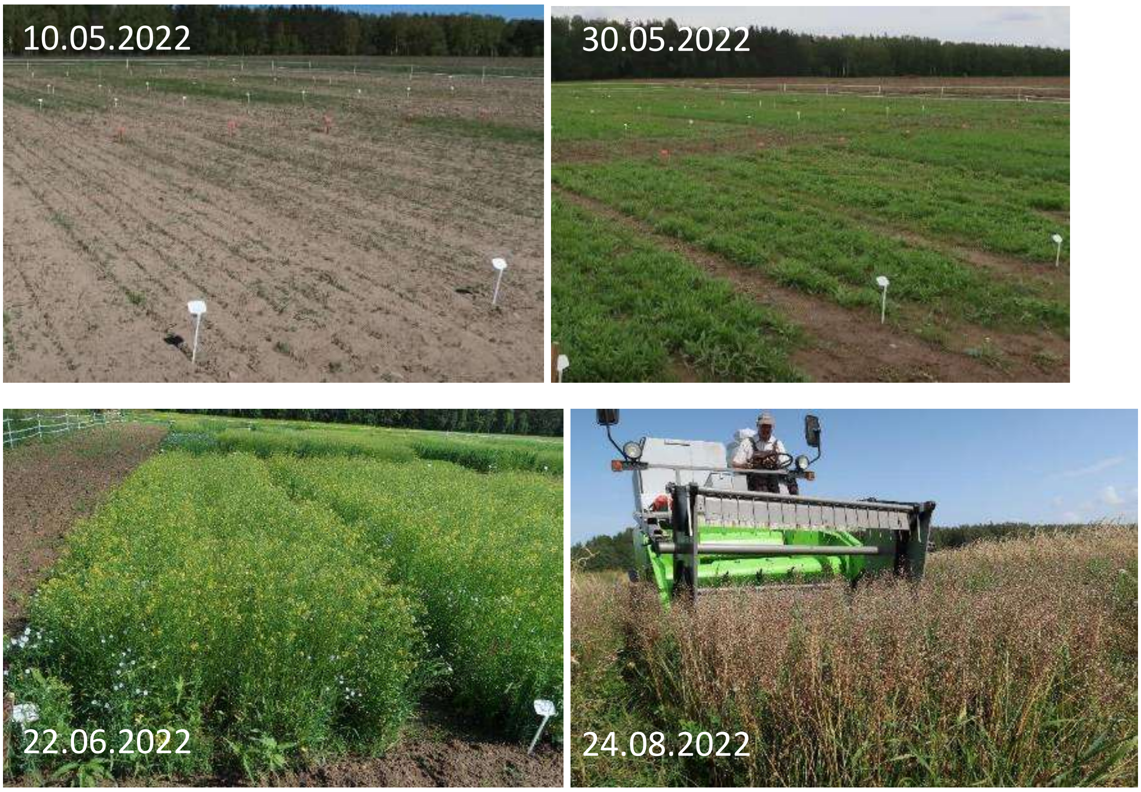


Fig. 18. Plant growth and development in small scale trials in 2022

Fig. 19. Plant growth and development in small scale trials in 2023

Fig. 20. Plant growth and development in small scale trials in 2024

The data on seed yield exhibited a distribution different from a normal distribution. Therefore, the statistical analysis was performed using the Kruskal-Wallis test. The results showed a statistical differentiation between the yields from the individual cultivation systems (P<0.001) (Fig. 21, Table 14). The yields of camelina from the sole cropping and intercropping systems did not differ from each other and ranged from 1.22 to 0.54 Mg/ha. (for sole camelina cropping and camelina intercropped with spelt sown in low density, respectively). The exception was the seed yield of camelina from intercropping with spelt (high density), where it differed significantly from camelina sole cropping and amounted to 0.33 Mg/ha. The results also showed that companion crops, in the intercropping system, were characterized by a lower seed yield compared with their sole cropping. However, these differences are statistically insignificant. This was influenced by exceptionally high variability in yields obtained from individual plots and years. It can be concluded, however, that intercropping systems, despite lower yields, were characterized by higher stability compared to sole cropping systems (Fig. 21). Unfortunately, the low yields in sole cropping were also influenced by feeding of wild animals during the experiment, especially in spelt wheat (birds after sowing) and pea (hares and roe deer during crops growing phase) in 2024.

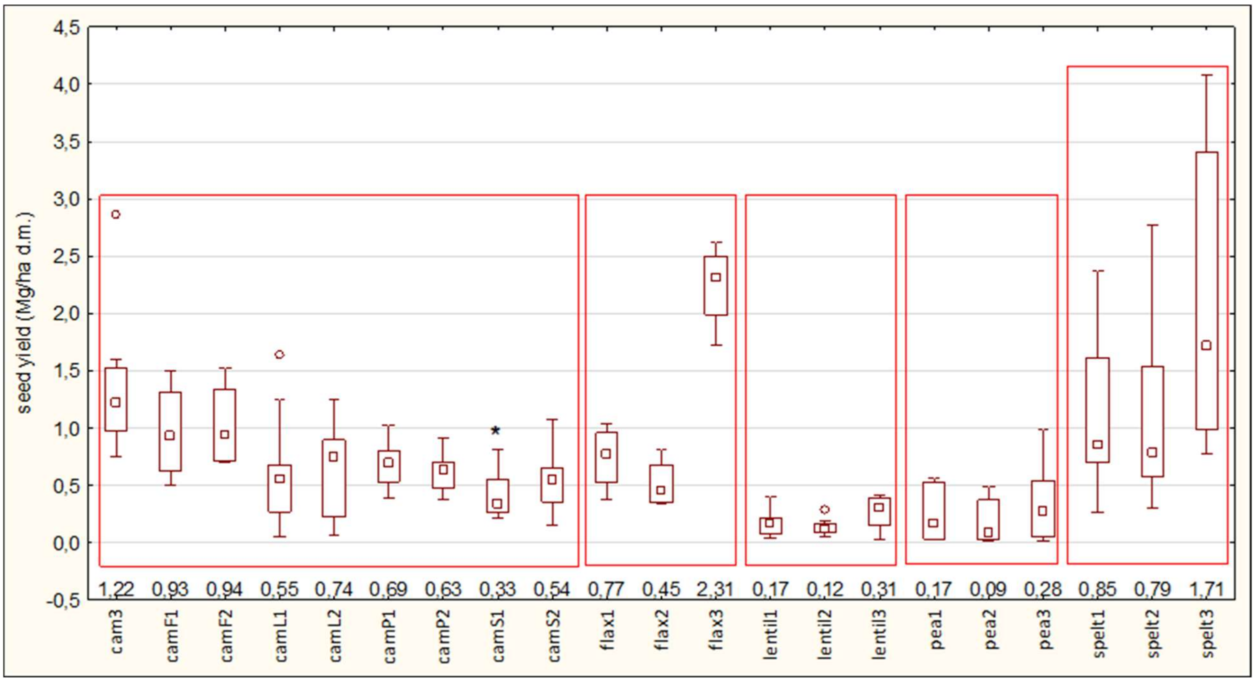


Fig. 21. Seed yields (median) from the entire trial conducted in years 2022-2024; asterisk in individual blocks separated by red rectangle shows significant differences in yields between sowing of each species in sole- and intercropping system. P<0.001 (Kruskal-Wallis test); cam3, flax3 lentil 3, pea 3, spelt 3.: camelina, flax lentil, pea and spelt cultivated in sole cropping system; camF1, cam L1, , cam P1, cam S1: camelina seed yields from the intercropping with flax, lentil, pea and spelt sown in high density; cam F2, camL2 , cam P2, camS2: camelina seed yields from the intercropping with flax, lentil, pea and spelt sown in low density; flax 1, lentil 1, pea 1 and spelt 1: seed yields of flax, lentil, pea and spelt intercropped with camelina in high sowing density; flax 2, lentil 2, pea 2 and spelt 2: seed yields of flax, lentil, pea and spelt intercropped with camelina in low sowing density

Total seed yields from individual cultivation systems are presented in Figure 22. The highest yield from the intercropping system was obtained for the cultivation of camelina and flax sown in high density. Also, the land equivalent ratio (LER) for this system was favourable and amounted to 1.10. The yield of camelina and lentil sown in law density had LER 1.01, while the other intercropping systems had LER<1. This means that intercropping systems did not show better land use in comparison to sole cropping systems. Despite the fact that the LER for camelina and flax sown in high density was favorable, it is very likely that on a commercial scale it will be lower. This is due to the fact that, on small experimental plots, there was a noticeable tendency for flax to be suppressed by camelina in the middle parts of the plots, while flax primarily grew along the plot edges. Moreover, flax was sown only in the first year of the experiment (2022), which was more favourable for plant growth. Due to the noticeable edge effect, the crop was eliminated from the experiment in 2023 and 2024.

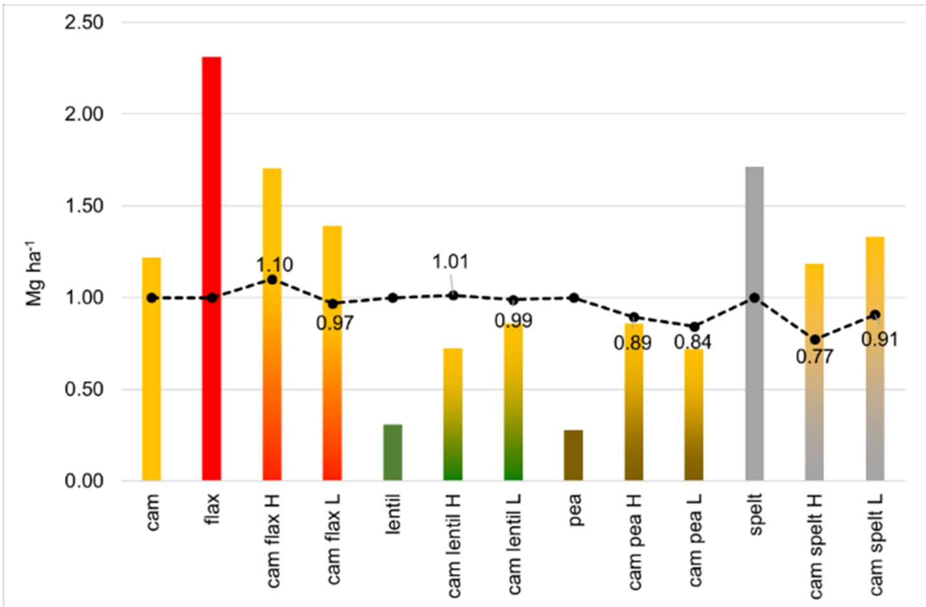


Fig. 22. Total dry seed yields and land equivalent ratio from sole cropping systems and camelina intercropping with flax, lentil, pea and spelt from years 2022-2024. Bars represent median and line land equivalent ratio

Crop performance indices for the intercropping systems are presented in Table 16. In most systems, the total LER was close to or slightly above 1, suggesting efficient use of land, but the CPR, which takes into account the seeding ratio, showed that only in two cases (Camelina x flax H and Camelina x spelt L) were intercropping systems more efficient than sole cropping systems. Furthermore, in most combinations camelina was suppressed by the companion crops (CR < 1, A < 0).

Table 16. Land equivalent ratio (LER), Relative Crowding Coefficient (K), Aggressivity (A), Competitive Ratio (CR), Crop Performance Ratio of the intercropped systems of UWM trials in 2022-2024

	LER			Relative Crowding coefficient			Aggressivity index		Competitive ratio		Crop Performance Ratio
Intercropping system	Cam e	Com p	Tot al	Came	Comp	Total	Came	Comp	Cam e	Comp	
Came x lentil H	0.45	0.56	1.01	2.78	0.38	1.06	-0.11	0.11	0.24	4.14	0.72
Came x lentil L	0.61	0.38	0.99	7.43	0.13	0.95	0.23	-0.23	0.34	2.96	0.81
Came x pea H	0.57	0.61	1.18	5.51	0.38	2.08	-0.05	0.05	0.22	4.54	0.83
Came x pea L	0.52	0.33	0.84	6.43	0.08	0.52	0.19	-0.19	0.26	3.80	0.66
Came x spelt H	0.27	0.50	0.77	1.36	0.27	0.37	-0.22	0.22	0.15	6.55	0.90
Came x spelt L	0.45	0.46	0.91	4.14	0.17	0.69	-0.01	0.01	0.19	5.26	1.03
Came x flax H	0.77	0.33	1.10	4.28	0.38	1.64	0.43	-0.43	1.74	0.57	1.01
Came x flax L	0.77	0.20	0.97	6.23	0.13	0.83	0.58	-0.58	2.16	0.46	0.87

Table 15. P value for multiple comparisons (bilateral); seed yield (Mg/ha); Kruskal-Wallis test, P<0.001

	cam3	**pea3**	**spelt3**	**lentil3**	**camP1**	**camS1**	**camL1**	**camP2**	**camS2**	**camL2**	**pea1**	**spelt1**	**lentil1**	**pea2**	**spelt2**	**lentil2**	**flax3**	**camF1**	**camF2**	**flax1**	**flax2**
cam3*		0.017	1.000	0.001	1.000	0.048	0.676	1.000	0.607	1.000	0.002	1.000	0.000	0.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000
pea3	0.017		0.004	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.674	1.000	1.000	1.000	1.000	0.068	1.000	1.000	1.000	1.000
spelt3	1.000	0.004		0.000	1.000	0.010	0.189	1.000	0.167	0.596	0.000	1.000	0.000	0.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000
lentil3	0.001	1.000	0.000		1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.082	1.000	1.000	0.172	1.000	0.014	1.000	1.000	1.000	1.000
camP1	1.000	1.000	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.409	0.768	1.000	0.155	1.000	1.000	1.000	1.000	1.000
camS1	0.048	1.000	0.010	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.202	1.000	1.000	1.000	1.000
camL1	0.676	1.000	0.189	1.000	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
camP2	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.523	1.000	1.000	1.000	1.000	1.000
camS2	0.607	1.000	0.167	1.000	1.000	1.000	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
camL2	1.000	1.000	0.596	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000	0.933	1.000	1.000	0.339	1.000	1.000	1.000	1.000	1.000
pea1	0.002	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		0.112	1.000	1.000	0.214	1.000	0.014	1.000	1.000	1.000	1.000
spelt1	1.000	0.674	1.000	0.082	1.000	1.000	1.000	1.000	1.000	1.000	0.112		0.003	0.015	1.000	0.001	1.000	1.000	1.000	1.000	1.000
lentil1	0.000	1.000	0.000	1.000	0.409	1.000	1.000	1.000	1.000	0.933	1.000	0.003		1.000	0.007	1.000	0.001	0.412	0.188	1.000	1.000
pea2	0.000	1.000	0.000	1.000	0.768	1.000	1.000	1.000	1.000	1.000	1.000	0.015	1.000		0.032	1.000	0.003	0.600	0.293	1.000	1.000
spelt2	1.000	1.000	1.000	0.172	1.000	1.000	1.000	1.000	1.000	1.000	0.214	1.000	0.007	0.032		0.002	1.000	1.000	1.000	1.000	1.000
lentil2	0.000	1.000	0.000	1.000	0.155	1.000	1.000	0.523	1.000	0.339	1.000	0.001	1.000	1.000	0.002		0.000	0.193	0.084	0.841	1.000
flax3	1.000	0.068	1.000	0.014	1.000	0.202	1.000	1.000	1.000	1.000	0.014	1.000	0.001	0.003	1.000	0.000		1.000	1.000	1.000	1.000
camF1	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.412	0.600	1.000	0.193	1.000		1.000	1.000	1.000
camF2	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.188	0.293	1.000	0.084	1.000	1.000		1.000	1.000
flax1	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.841	1.000	1.000	1.000		1.000
flax2	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	

*cam3, flax3 lentil 3, pea 3, spelt 3: camelina, flax lentil, pea and spelt cultivated in sole cropping system; camF1, cam L1, , cam P1, cam S1: camelina seed yields from the intercropping with flax, lentil, pea and spelt sown in high density; cam F2, camL2 , cam P2, camS2: camelina seed yields from the intercropping with flax, lentil, pea and spelt sown in low density; flax 1, lentil 1, pea 1 and spelt 1: seed yields of flax, lentil, pea and spelt intercropped with camelina in high sowing density; flax 2, lentil 2, pea 2 and spelt 2: seed yields of flax, lentil, pea and spelt intercropped with camelina in low sowing density

6. Conclusions

All the intercropping trials established within SCOOP permitted to highlight great potential in the combination of camelina with different underutilized crops. The majority of the trials succeeded to achieve LER higher than 1, thus confirming the possibility to improve the use of soil under organic farming by growing camelina and a companion crop together. The few failures occurred were mainly due to unpredictable adverse weather conditions, and only in limited cases (i.e., naked oat Italy) to the high competitiveness of the companion crop over camelina. In general, it was possible to identify for each of the test countries a more promising combination which was tested in larger field trials within task 2.3, and this was the case of chickpea and lentil in Italy, fenugreek in Turkey, spelt in Poland and vetch in Bulgaria.