NUTRIENT CONSUMPTION OF SOME NON-TRADITIONAL ENERGY CROPS

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Abstract

The need of finding renewable energy sources arouse quest of low-input crops in order to achieve positive energy balance of the production chain. Several non-traditional oil crops were tested in two different soil-climatic regions. The selected crops were cultivated in the country in the past and are not very pretentious low-input crops: Crambe (Crambe abyssinica), Camelina (Camelina sativa), Lalemantia (Lalemancia liberica), Castor bean (Ricinus communis), Safflower (Carthamus tinctorius), Sylibum (Silybum marianum), pumpkin (Cucurbite pepo). These crops were compared with traditional oil crops – sunflower, rape. In order the whole energy yield to be estimated, the plant residues were analyzed for fiber content.

In the study the N, P, K, Ca, Mg consumption for 100 kg oil and flax are determined. The crops are ranked according to nutrient needs.

Introduction

Demand of finding renewable energy sources takes a great notice of bioenergy crops. Some of the main differences between the requirements for energy cropping versus food and feed cropping are: a positive energy balance, use of species valued for their energy content not for their nutrient content, the whole crop is used, energy crops may be grown on set-aside land. The need to achieve positive energy balance of the production chain - growing, harvesting and processing arouses quest of low-input crops. In this respect of interest is selecting suitable for bioenergy production and more adaptive crops (Joaris A., 2007). Beside other inputs, energy cost of fertilizers has to be taken into consideration (El Blasam, N., 1998, Venturi P.at all, 2003). A lot of experience is available on growing crops for food designation, while there is only limited experience with growing dedicated bioenergy crops.

The main object of the study is to compare the nutrient consumption of some non traditional and traditional crops for producing 100 kg seeds, 100 kg oil in the seeds and 100 kg flax in the plant residues.

Matherials and methods

Several non-traditional oil crops were tested in two different soil-climatic regions in Bulgaria – Vrajdebna – "V" (Chromic Luvisols, medium to high nutrient content in the soil; annual precipitations – 606 mm) and Barzia - "B" (Eutric Planosols, low nutrient content in the soil; annual precipitations – 825 mm). The selected crops, suiting for biodiesel production, were cultivated in the past in the country and are not very pretentious low-input crops: Crambe (Crambe abyssinica), Camelina (Camelina sativa), Lalemantia (Lalemancia liberica), Castor bean (Ricinus communis), Safflower (Carthamus tinctorius), Sylibum (Silybum marianum), pumpkin (Cucurbite pepo).

These crops were compared with traditional for the country oil crops – sunflower and oil seed rape.
The experiment was carried out with only single N fertilization (60 kg/ha) and without irrigation in order to compare the crops under low-input conditions. During the second year 30 kg/ha P2O5 were applied in Barzia because of very low phosphate content in the soil. The chemical composition of seeds and plant residues was determined. In order the whole energy yield to be estimated, the seeds were analyzed for crude oil content and the plant residues for crude fiber content. The N, P, K, Mg and Ca removals for producing 100 kg seeds, oil or flax were calculated on the basis of seeds and biomass yields, resp. oil and flax yields and chemical composition. The average data of two experimental years are presented.
The study is conducted within the framework of a 3 years project "Bio- and energy potential of non traditional crops", financed by the Ministry of education and science.

Results and discussion
Generally, the yields of the crops were relatively low not only because of low input technology but also because of adverse meteorological conditions during the vegetation periods (high summer temperatures, accompanied with low air humidity, in 2008 - extremely intensive rain in August after long dry period). The yields in Barzia during the two years were 30-50% lower than in Vrajdebna because of lower soil fertility. From the traditional oil crops better yields were obtained from sunflower in Vrajdebna. On both locations oil seed rape gave low yields. From the non traditional crops lalemantia was the crop giving better and sustainable seed yields on both locations and safflower in Vrajdebna. The oil yields from different crops were also calculated. The highest oil yield was obtained from sunflower because of its higher oil content. From the non traditional crops higher oil yields gave lalemantia. It could be mentioned that for all nutrients pumpkin is the crop with highest nutrient consumption for producing 100 kg seeds or oil because the seeds portion in fruit and whole plant mass is small.

NITROGEN - The nitrogen removal for 100 kg **seeds** is quite different - between 4.1 and 16.8 kg in Vrajdebna (V) and 2.9-32.0 kg in Barzia (B) (Fig. 1). In location V highest nitrogen consumption have crambe and oil seed rape, crops with low seed yields. For the rest of the crops the N removal is 4.1-6.4 kg and the lowest is for castor bean and lalemantia. In location B the differences between the crops are bigger than in location V. Castor bean shows the highest N removal because of the low seed yield. Here the traditional oil crops – sunflower and oil seed rape show high nitrogen consumption. Again lalemantia is the crop showing lowest N removal.
The nitrogen consumption for 100 kg **oil** also shows big differences between the crops - 12.8 - 79.3 kg in Vrajdebna from 13.1 to 134 kg in Barzia. In location V lowest N consumption for 100 kg oil is observed for sunflower – 12.8 kg because of highest oil content in the seeds and high yield. In contrast, oil seed rape show very high consumption because of very low seed yield. High quantity N for 100 kg oil is needed also for crambe, pumpkin and sylibum. From the non traditional crops lowest N removal is for castor bean and lalemantia but it is about 40% more than for sunflower. In location B highest N removal for 100 kg oil has castor bean. The reason is relatively low seed yield together with high biomass yield. For the rest of the crops in Barzia the highest N consumption for 100 kg oil is for traditional crops – sunflower and oil seed rape because of relatively low seed yields. Lalemantia has the lowest N need – 4.5 times less than for the traditional crops.

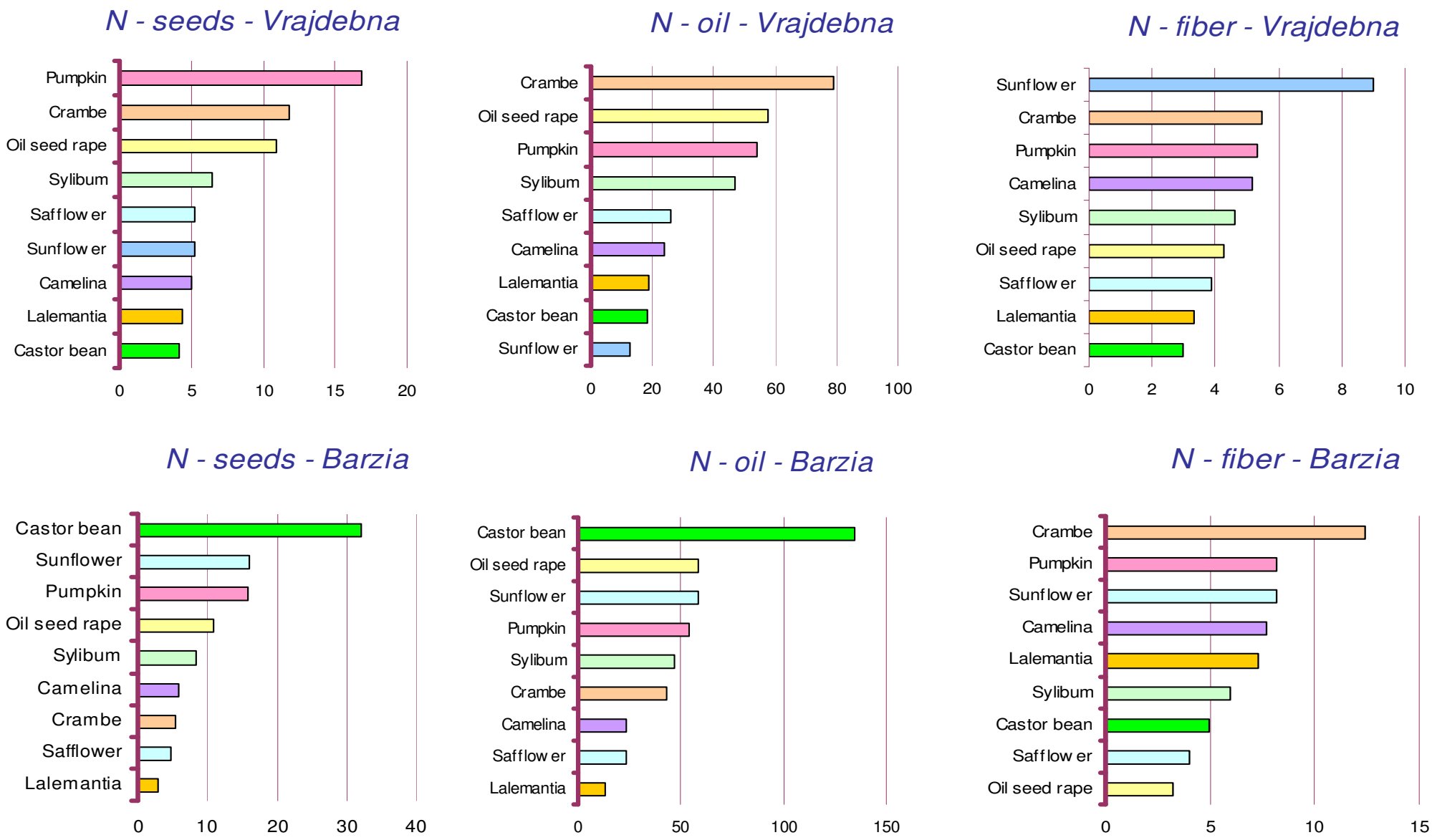

Fig.1 - Nitrogen comsumption (kg/100kg)

From the data presented is evident that **lalemantia** is a crop with lowest nitrogen consumption for 100 kg seeds and oil on both locations. From the traditional oil crops better results show sunflower in Vrajdebna but not on the other location. Oil seed rape gave in to sunflower on both locations because of non sustainable yields.

PHOSPHORUS - The phosphorus removal for 100 kg **seeds** is between 0.9 and 3.4 kg in Vrajdebna and 0.7-3.9 kg in Barzia (Fig. 2). In location V, high P consumption shows crambe because of its very low yield. The most economical P consumption is observed for **camelina** - 33 % less than the next crop. The rest of the crops do not differ significantly (1.2-1.6 kg) and between them the traditional crops show higher P demand. In location B the traditional oil crops have higher P demand compare to the non traditional crops. Lalemantia has lowest P consumption for 100 kg seeds and it is 4.8 times less than for 100 kg sunflower seeds.
The phosphorus consumption for 100 kg **oil** is between 4.4 and 22.6 in Vrajdebna and between 3.12 and 12.95 kg in Barzia. The P needed for 100 kg oil in Barzia is on average about 15% lower than in Vrajdebna. In location V higher P removal is for crambe, followed by sylibum – 3-5 times more than lowest P removal. The lowest P consumption for 100 kg oil, like for 100 kg seeds has camelina**,** 40% less than the next crop. Sunflower and oil seed rape show equal P removal and it is 2 times more than for camelina oil. In location B pumpkin, sunflower, oil seed rape and castor been has high P consumption, more than 10 kg per 100 kg oil. The other, non traditional crops need less phosphorus (3-7 kg). Lalemantia and camelina are the crops with lowest P needs for 100 kg oil.
The data presented show that **camelina** and **lalemantia** are the crops with lowest phosphorus consumption for 100 kg seeds and oil on both locations. The differences with the other crops are bigger in Vrajdebna. Generally, the traditional oil crops have higher P consumption than the non traditional.

POTASSIUM - The potassium removal for 100 kg **seeds** is between 1.9 and 18.3 kg in Vrajdebna and 0.8-18.6 kg in Barzia (Fig. 3). In location V, except pumpkin and crambe, the rest of the crops have 2-6 kg removal. The lowest K consumption for 100 kg seeds shows camelina – 73.7% less than the next crop, 2.3 times less than sunflower and 2.8 times less than oil seed rape. In location B, except pumpkin, the highest K consumption have traditional oil crops – sunflower and oil seed rape. The K needed for 100 kg non traditional oil seeds is lower for crambe, lalemantia and camelina – 0.8-2.7 kg. A higher K demand has Castor bean (9.5 kg).
The potassium consumption for 100 kg **oil** is between 9.6 and 59.2 kg in Vrajdebna and between 6.1 and 61.2 kg in Barzia. The differences between the crops are bigger than the needs for 100 kg seeds. In contrast to P, the potassium needed for 100 kg oil in Barzia is on average about 30% higher than in Vrajdebna. In location V higher K removal has crambe because of its low oil content, followed by pumpkin and sylibum – 5-6 times more than lowest K removal. The lowest K consumption for 100 kg oil, like for 100 kg seeds has camelina, 18 % less than the next crop – sunflower and 29% less than oil seed rape. In location B very high potassium demand is observed for sunflower, oil seed rape, pumpkin and castor been - more than 50 kg per 100 kg oil. The other, non traditional crops need less potassium (10-20 kg). Crambe, lalemantia and camelina are the crops with lowest K needs for 100 kg oil.

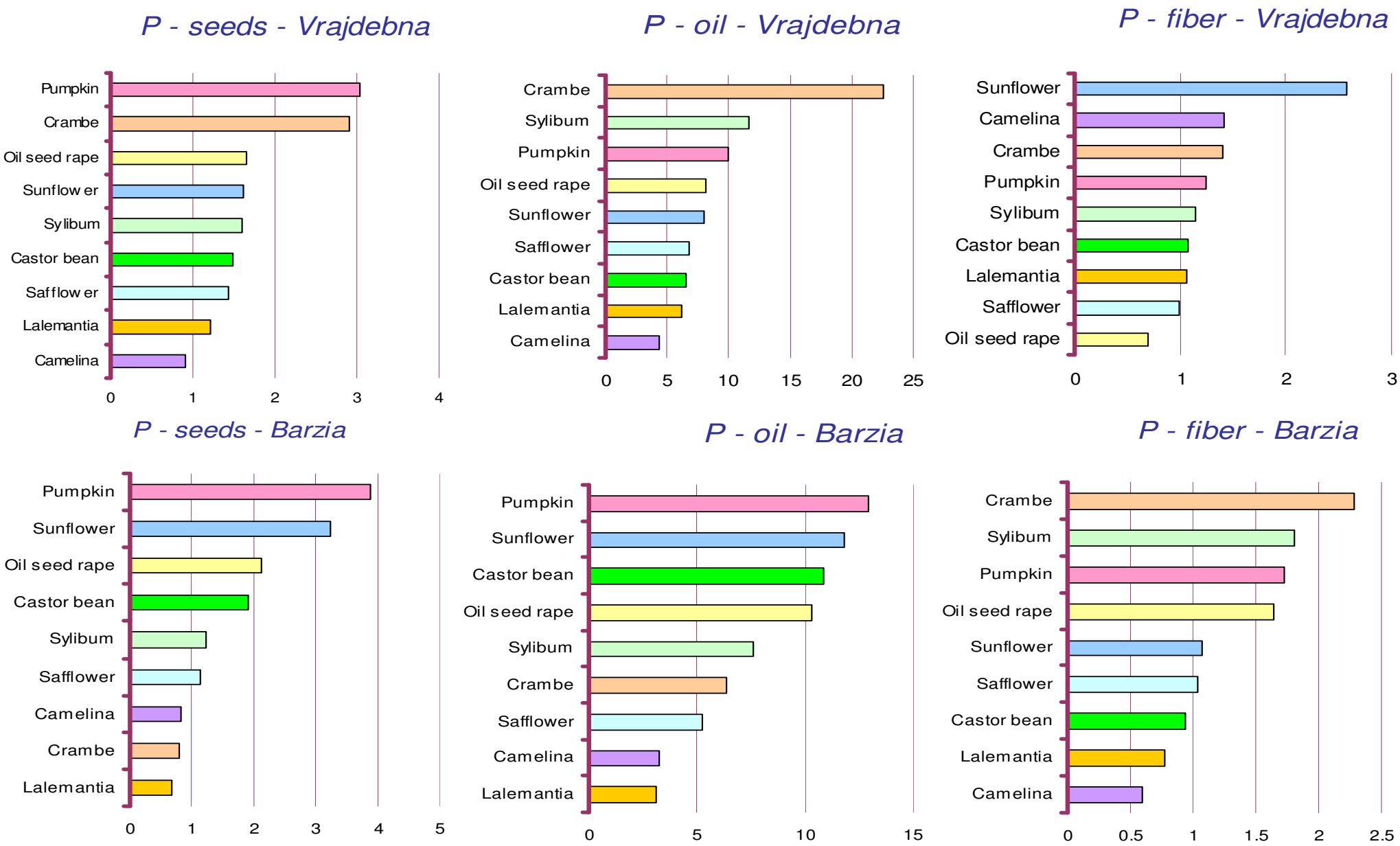

Fig.2 - Phosphorus comsumption (kg/100kg)

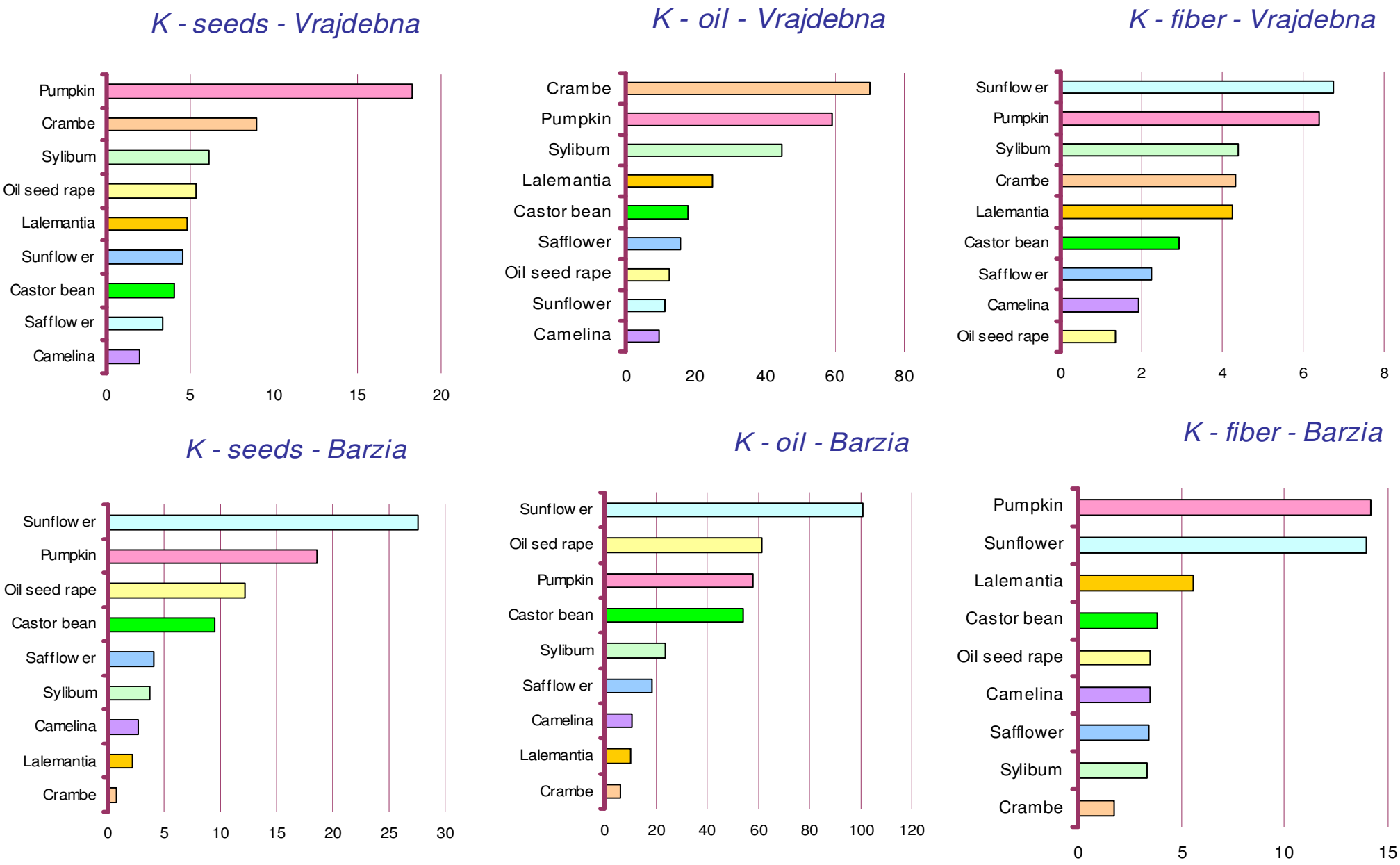

Fig.3 - Potassium comsumption (kg/100kg)

From the data presented is evident that **camelina** and **lalemantia** are the crops with lowest potassium consumption for 100 kg seeds and oil on both locations. Traditional crops show different ranking for the two sites. Both sunflower and oil seed rape have lowest K consumption for 100 kg oil in location V and highest for location B because of differences in seed yields and oil content on both location.

MAGNESIUM - The magnesium consumption for 100 kg seeds is between 0.5 and 2.6 kg in Vrajdebna and 0.3-6.4 kg in Barzia. Sunflower, sylibum and oil seed rape have high Mg removal. Camelina and lalemantia show lowest Mg demand in Vrajdebna – 24% less than the next crop. In Barzia crambe, camelina and lalemantia needs 3 to 10 times less Mg than the rest of the crops.
High Mg demand for 100 kg oil is observed for sylibum on location V and castor bean and sunflower for location B. Relatively low is the Mg consumption for **camelina and lalemantia** for both locations.

CALCIUM - The calcium consumption for 100 kg seeds is between 1.4 and 22.2 kg in Vrajdebna and 1.1-21.9 kg in Barzia. Very high Ca consumption show sylibum on location V and castor bean on location B. Sunflower and oil seed rape have high Ca removal. Camelina and lalemantia show lowest Ca demand on both locations.
High Ca demand for 100 kg oil is observed for sylibum on location V and castor bean on location B. Relatively low is the Ca consumption for **sunflower** and camelina for location V and **camelina** and lalemantia for location B.
The nutrient consumption for producing a unit **fiber** is lower and the differences between the crops are not as big as for producing unit oil. From nutrients the highest is nitrogen consumption – 3-12 kg/100 kg fiber. Somewhat less are the potassium (1-14 kg/100 kg fiber) and calcium consumptions (1-16 kg/100 kg fiber). Lowest is the need of phosphorus (0.7-2.6 kg/100 kg fiber) and magnesium (0.5-3.5 kg/100 kg fiber). The highest nutrient need for unit fiber shows again pumpkin. From the rest of the crops high nutrient removal for fiber production has sunflower, mainly because of high nutrient content, while the other traditional oil crop – oil seed rape has lowest removal. From the non traditional crops low nutrient removals have **lalemantia, camelina** and partly crambe and castor bean.
The data review show that the oil crops have different nutrient demands per unit oil producing. In order to compare the energy costs for fertilizers, the N, P and K removals were expressed in energy equivalents according to Pimental D.,1984 (N - 77,5, P2O5 – 14, K2O – 9,7 mJ). The results show great distinction between the crops. In Vrajdebna the nutrient energy equivalent is 1160 – 8375 mJ. In Barzia it is 1157 – 5690 mJ. There are differences between the nutrient energy costs for unit oil for the same crops, grown on different sites as well. This refers to a great extent to sunflower and castor bean; the energy cost on location B is resp. 5 and 6 times higher than in location V. The crop ranking show lowest energy cost for **camelina** – 26% less than the second crop - sunflower in Vrajdebna. For Barzia the lowest energy cost has **lalemantia** – 65 % less than the next crop (camelina). The oil seed rape has relatively high energy cost for producing unit oil on both locations – about 5 times more than the lowest E cost. The crops' ranking according to the nutrient energy costs arranges somewhat different the crops than for seed or oil yield. It shows that the nutrient consumption of different crops is important parameter for energy balance. Having in mind that nitrogen has the biggest share of the nutrient energy costs (70-85 %) the interest could be focused on N needs of the crops. In the study the lowest N consumption for unit oil production have lalemantia on both locations and sunflower in Vrajdebna.

Conclusion:
There are big differences between studied crops concerning the nutrient demands per unit seeds or oil. Pumpkin spends high quantity of nutrients because of great amount secondary biomass. Lalemantia and camelina are the crops with lower nutrient demand for producing 100 kg seeds or oil because of sustainable yields during the two years and relatively high oil content in the seeds. The traditional for the country oil crops – sunflower and oil seed rape show variable results depending on the site and the year. Generally for the traditional crops, the tendency is in favor with sunflower; oil seed rape gave way to sunflower in many respects.
The nutrient energy costs for producing unit oil also show big differences between the studied crops. The ranking outlined camelina in Vrajdebna and lalemantia in Barzia as crops with lowest nutrient energy demands.
The results show that taking into account the nutrient energy costs for producing unit oil for every one oil crop is important for improving the energy balance of the biodisel production chain.

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