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## CULTIVATION OF ALTERNATIVE CROPS IN THE EASTERN RHODOPEs IN BULGARIA

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**Abstract:** At a time when the introduction of any novelty in production or agriculture is being considered in the light of the damage to nature, and society is finally beginning to measure its technological progress with the degree of conservation, alternative crops are turning out to be a small fortune. The pursuit of sustainable development, declining agro-biodiversity and the health benefits associated with unique nutritional qualities are the main reasons for exploring and growing new alternative crops. The purpose of this study is to develop efficient agricultural production and the application of alternative agriculture in the area. The reasons for the need of the study are the fragmented and low-fertile land and the orientation of the Rhodopes agriculture towards ecological production and the requirements of the European market. The study included fiber, energy, oil and protein crops as alternative tobacco crops in the geographical territories of the Eastern Rhodopes - the districts of Kardjali and Haskovo. It was found that the fields with annual crops in the lands of the town of Ivaylovgrad in the Haskovo district realized higher yields than the respective studied crops. Of all the thirteen crops, the highest development and high yields were found in spelled, triticale, safflower, miscanthus, olives and almonds during the study period, and yields of hemp, flax, rapeseed, soybean, sorghum and buckwheat were unsatisfactory.

**Keywords:** alternative crops, protein crops, *Olea europaea*, oil crops, energy crops, fiber crops.

### INTRODUCTION

What does it mean to grow alternative crops? It's a question we keep asking ourselves. Namely, the pursuit of sustainable development, the diminishing agrobiodiversity and the health benefits associated with unique nutritional qualities are the main reasons for exploring and exploring new alternative crops.

The reform of the global tobacco market and changes in agriculture, in line with EU requirements, have a strong impact on Bulgaria's tobacco economy. These changes have a particular impact on typical tobacco production areas, with the main industry being tobacco production. Over 60-65% of the agricultural land in the Rhodope region is occupied by natural meadows and pastures. At the same time, the region has vast areas of natural grassland. In recent years, both meadows and grasslands have been abandoned and have gradually become desert and shrubby areas. Now only 10-15% of natural meadows and pastures are used.

The issue of non-desertification of land and provision of alternative employment for the active population in the Eastern Rhodopes is a matter of urgency, which raised the question to scientists "whether the soil and climatic conditions of the Eastern Rhodopes allow a successful cultivation of a set of alternative crop groups."

The purpose of this study is to develop efficient agricultural production and alternative agriculture through the opportunities for adaptation and cultivation of fiber, energy, oil and protein crops in the geographical territories of the Eastern Rhodope Massif - municipalities with predominantly mountainous regions in Haskovo and Kardzhali, as alternative tobacco crops.

### **MATERIALS AND METHODS**

The soil and climatic conditions of the Eastern Rhodopes make it possible to grow a range of fiber, protein, oil and energy crops. Suitable under non-irrigation conditions are triticale, rapeseed, flax, sorghum, almonds, walnuts, legumes, miscanthus and more. When irrigated, olives, buckwheat, hemp and soybean can be grown.

The experimental study included 13 types of annual and perennial fiber, oil, protein and energy crops in the Eastern Rhodopi region of southern Bulgaria, in the lands of the districts of Kardjali and Haskovo. Bulgarian and Spanish varieties of olives, walnuts, almonds, sorghum, triticale, spelled, soybean, safflower, buckwheat, hemp, flax, miscanthus and rapeseed, characterized by their quantitative and qualitative indicators, were included in the study to solve the set tasks.

Experience shall be conducted in a uniform manner, subject to all requirements established in practice, such as betting practices; drawing, sowing and planting; creation of a supporting structure; care during the growing season; fertilization; harvesting and production of oil, protein, fiber and biomass. The varieties used are planted on abandoned arable land, according to the requirements of a standard cultivation scheme for each crop. For the fruit species, the requirement for the planting direction is from north to south. An exception is made only in hilly areas where the slope of the hill is followed to facilitate harvesting. Before sowing and planting, fertilization of areas with 3-4 t of manure was carried out; 150-200 kg / da super phosphate and 100kg / da potassium. Deep plowing of 60 - 80 cm and creation of planting pits of dimensions 60x60x60cm was carried out. The trees are planted during the period October-November, and after the planting they are obligatory to be abundantly covered with water and attached to a support structure or bamboo stalks, and annual crops in the optimum time of sowing of the respective type of crop. Care during the growing season for the reporting period is in accordance with established guidelines and requirements.

During the growing season phenological (pomological) observations were made, reported according to the commonly used methodology for conducting field experiments. The onset of sapling and emergence was reported at 10% and complete at 75% sapling and emergence of field plants.

#### 1. Main highlights for the successful cultivation of protein crops in this region of the country

The best sources of vegetable proteins include legumes in the form of beans, lentils, lupins (yellow beans) peas and chickpeas. Soy beans play an exceptional role, from which many interesting products are produced: tofu, soy beans, soy fresh and yogurt. Many proteins are also

present in nuts (especially in peanuts, cashews, pistachios, almonds, nuts) and seeds (sunflower seeds, sesame seeds, pumpkin seeds). Proteins are the basic building blocks in the cellular structures of living organisms. Depending on the soil and climatic conditions of the area, the following species are selected:

1.1 Einkorn wheat (*Triticum monococcum*) (spelled) is a durable crop that is slightly dependent on climatic conditions. It can survive and grow on poor soils where wheat cultivation is unthinkable. Most of the areas in Kardzhali are such. Rich in protein, vitamins A, B, E and minerals. It is a powerful antioxidant and bioproduct with healing properties. It is suitable for people with gluten intolerance in white wheat flour.

1.2 Buckwheat (*Fagopyrum esculentum*) is gluten free grain and more protein. It has a unique amino acid profile as it is high in arginine and lysine. It has the power to increase the protein value of cereals and legumes. It is a heat-loving, light-loving and water-loving plant. Buckwheat grows well on fertile soils. Unlike other cereals, there is a short growing season, which makes it extremely suitable as a second crop after early precursors such as rapeseed and barley. Buckwheat is grown in various parts of the country due to the high honey content of its flowers.

1.3 Triticale (*Triticosecale*) was created by crossing wheat with rye and is a new cereal crop. Its grain is used as fodder, and wheat and triticale flour yields good-quality dietary bread. In addition to grain, triticale is grown for a green mass that is richer in protein than rye. In addition to its high productivity and nutritional value of grain and green mass, triticale has other valuable qualities. It is less demanding on soil and climatic conditions and is more resistant to fungal diseases.

1.4 The soya bean (*Glycine max*) is a species of legume and is extremely rich in protein, lecithin, omega-3 polyunsaturated fatty acids, and is a source of vitamins and minerals. Soy protein is a valuable raw material in the production of meat and milk analogues. The yield of soy protein per acre is significantly greater than any other crop used. Soybean is a heat-loving and water-loving plant and is one of the most sensitive to the photoperiod of plants. It grows best on rich and well-aerated soils. Due to lumps, it does not tolerate heavy, swampy, salty and acidic soils.

1.5 The fruits of the walnut are rich in fat, protein, vitamins, minerals. It grows well in areas with altitudes up to 700-800 m, but is up to 1300 m in forest plantations. It grows in relatively warmer parts of the temperate continental zone, but is plastic and can acclimate to northerly areas.

1.6 Almond kernels are very rich in dry matter, with fat, protein and carbohydrates accounting for the largest part. Almond is not demanding on soil. It grows well on different soil types, including not very rich in humus content. Heavy clay and non-draining soils as well as soils with shallow maternal rock or clay horizon are unsuitable. Almond is the most dry plant of the tree-grown fruit species in our country. This allows almonds to be grown on sloping and irrigated areas.

## 2. Main highlights for the successful cultivation of oilseeds in this region of the country

The group of oilseeds includes cultivated plants which are grown mainly for seeds or fruits with high fat content. Vegetable oils are more dietary and healthier than animal oils, which is why their worldwide production is steadily increasing. Suitable for the Eastern Rhodopes are:

2.1 Basically rapeseed (*Brassica napus*) is used for feed, rapeseed oil and biodiesel. Rapeseed is a drought-resistant oilseed plant that is already used for biofuel production. Rapeseed requires a temperate climate. It is a cold-resistant culture. Rapeseed is a long-day plant. It tolerates different soil types - black soil, alluvial, gray, cinnamon and brown forest soils. It is also cultivated on weaker soils in sub-mountainous areas where other crops produce poor results. Rapeseed requires neutral but develops well in slightly acidic and slightly alkaline soil reactions.

2.2 Safflower (*Carthamus tinctorius*) is not soil-demanding. It is a dry and cold resistant herb. It could be sown in those areas where sunflower yields are low, because it is colder and more dry. The oil has a high content of linoleic acid and a low content of saturated fatty acids, which is a prerequisite for lowering blood cholesterol. Safflower oil can be used for nutritional purposes. Except in the food industry - for the production of margarine, as an adjunct to various dressings and as a starting material for hydrogenation, the oil is used for technical purposes, in medicine and cosmetics. Due to its easy dryness, safflower oil is also sought after in the paint industry.

2.3 Olive is one of the oldest and most common plants in literature, mentioned even in the Bible. Over the years, it has become a symbol of peace, wisdom, glory, fertility, strength and purity. The olive tree is the only one of its group with edible fruits. As a tree from the Mediterranean area, dry tropical climate, it adapts well to extreme climatic conditions, but requires very intense light and oxygen-rich soil (Tsolov, 1991; Nikolova, 2015; 2017; 2018). Olive trees are resistant to drought and disease. Their root system is durable and able to regenerate the tree, even when the trunk is frozen, burnt or cut off. They have a clear preference for limestone soils - limestone slopes and rocks. Prefer on light soils, poorer nutrients and warm weather. Withstands up to -16°C, one-time cold. Studies conducted in recent years (Espasa, 1981; Serafimov, 1983; Dirk, 2000; Brezovsky, 2003; Belaj, 2007) revealed that olive oil is not only a tasty food, but also an important source of good health. The benefits of olive plants have led us to think of adaptability and cultivation in Bulgaria as an alternative crop for the Eastern Rhodopes.

### 3. Main highlights for the successful cultivation of energy crops in this region of the country

Energy plants are crops grown specifically for energy purposes. They may be annual and perennial crops that serve as raw material for the production of solid, liquid and gaseous fuels. The leaves, stems and seeds of these crops may be used for processing. This definition does not include organic residues and wastes from a wide range of plants that can also be processed to produce fuels and which have significant potential. Biofuels are produced from naturally occurring renewable vegetable sources and their waste, which emits far less greenhouse gas than petroleum-based fuels.

3.1 Miscanthus - grown as a decorative and energy crop for biofuel production. Miscanthus species develop in relatively cold and warm climates. Miscanthus is one of the leading raw material crops based on exceptional biomass yields with minimal production input in recent European and American field trials. Miscanthus cultivation has huge advantages over other crops grown and used for energy. Compared to corn (ethanol), soybeans and millet, Miscanthus grass produces more total mass as well as more ethanol. Another great advantage of Miscanthus grass is that it is not a food crop and changes in demand will not have a direct effect on food prices. It grows well in sunny places, with enough moisture and grows well in barren lands. *M. giganteus* has higher photosynthetic efficiency, very low nutrient requirements and lower water use requirements than other plant species, and is therefore able to grow well on fertile land. It grows well in sunny places with enough moisture.

3.2 Cultured varieties of sorghum (*Sorghum bicolor*) are used for food, green and grain feed, silage, sugar syrup, starch extraction, and broom and alcohol production. Sorghum has valuable economic and biological features. It is a high yielding, drought resistant plant. Sorghum has a small leaf mass, which makes it a suitable crop for growing in very dry areas. Sorghum is a short-day plant and, as a warmer crop, does not tolerate temperatures below 0°C. Sorghum tolerates high temperatures. In general, sorghum is a plant with low moisture and soil requirements and can be grown on light sandy, heavy clayey, saline, alkaline or slightly acidic soils.

#### 4. Main highlights for the successful cultivation of fiber crops in this region of the country

4.1 Hemp (*Cannabis sativa*) is grown for its healthy fiber, high growth rate and seed fat. The fiber of hemp is coarse, strong and resistant to rot when wet. Hemp seeds are rich in oil, which is used to prepare varnishes and paint. The hemp cake is a very good concentrated feed for farm animals. Hemp has a powerful stem, but poorly developed and with little absorption root system. It is a water-loving culture and is too demanding on the soil. It is characterized by rapid growth, so it does not suffer from weeds because it easily suppresses them.

4.2 Fiber flax (*Linum hirsutum*) is a plant of temperate and cool climate, with no sharp fluctuations in day and night temperatures. It is moisture-loving and requires a lot of soil and air moisture through budding and flowering. Flax has a poorly developed root system and requires rich soil with easily digestible nutrients. The first days after emergence, it grows slowly and suffers from weeds. In the mountainous areas, flax is sown after potatoes, rye and oats.

In climatic terms, the Rhodope mountain range falls entirely in the Continental-Mediterranean climatic region of Bulgaria. The climatic conditions during the study period vary significantly by month and region (Table 1).

**Table 1.** Average quantitative values of the agro-climatic indicators in the Rhodope massif

Region	Average annual	$\Sigma$ precipitation		Balance of atmospheric humidity	Average annual air	$\Sigma$ T°C for the period with T°C >10°
	$\Sigma$ precipitation	April-June	April-September	April-September	temperature	
	mm	mm	mm	mm	°C	
Haskovo	615	190	310	-425	12.6	3 970
Kardzhali	800	200	315	-370	12.8	3 880

The total productive capacity of the land is characterized by an average (agronomic) credit score of 48, which assigns them to the “average land” credit group, but for most of the crops the bonus refers to the lower territories according to which they can be graded, such as “Bad lands” with a bonus in the range of 40 to 29 points. The average agronomic score for the region of Kardzhali is 40, for the region of Ivaylovgrad 57, and for the Rhodopes with an altitude below 1000m it is 48-51 points.

## RESULTS AND DISCUSSIONS

The territorial scope of the survey covers the territories in two districts (Kardzhali and Haskovo) in the Eastern Rhodopes (Figure 1).

To achieve a given purpose in an experimental study included 13 varieties of crops from four groups of crops - oil, protein, fiber, and energy crops.

Ivaylovgrad municipality is located in the southeastern part of the Rhodopes. The region's climate is transitional-Mediterranean. The territory of the municipality falls entirely within the East - Rhodope Physico - geographical area, with an altitude ranging from 70 to 700 m. The relief of the region has a distinct low-valley and valley character. The average annual rainfall is from 725 to 925 mm/m<sup>2</sup> and the average annual temperatures are 21-23°C.

On the territory of the municipality there are fields for adaptability of the Spanish olive, walnut and almond varieties, as well as growing of einkorn wheat, triticale, hemp, miscanthus and safflower, as alternative crops for the area. The experience is located between the highest and intermediate parts of the area.



**Figure 1.** The territory of the districts of Kardjali and Haskovo in the Eastern Rhodopes

The field was processed according to the requirements of the unified methodology for conducting field trials. In the field, a 60-65 cm plowing was done. Were planted 72 olive trees, 108 almonds and 144 walnuts according to a certain scheme, while the direction of sowing was kept from north to south. During planting, liquid fertilizer (rooting agent) was used to stimulate root growth („Tecamin Raiz”), 6-8 ml per tree. Fertilizer fertilization (Widstar) was applied at a dose of 200-400 g / 100 liters of water. Established 100% trees capture has been. Moisture is normal and no watering has taken place. To note the low values of morning temperatures in January (-10; -12°C) combined with snowfall and frost, which caused damage to 5-10% of the leaves and branches of the plants due to the reddening and blackening of the tip of the leaf petal. 0.6% of dead fruit plants were identified. The remaining plants are apparently powerful, green with good habit and new growth of 25% of them. There is no visible finding of damage by pests (diseases and pests).

In combination with favorable climatic conditions and high cultivation techniques for annual crops, 215 kg/ha of triticale, 110 kg/ha of safflower, 128 kg/ha of paddy spruce, 56 kg/ha of hemp and 420 kg/ha of dry miscanthus were harvested.

Miscanthus is a perennial cane energy crop. It has rapid growth, low mineral content and high biomass yield. She has reached a height of about 2.5 m, and the dry weight yield per year can reach 25 tonnes per hectare. In the European Union, it is used as a source of heat and electricity, or converted into biofuel products, such as ethanol.

Triticale is an artificial hybrid between wheat and rye and is a new cereal crop for the Rhodope region. The crop combines high productive potential and good wheat bread production with reduced soil requirements and plasticity for climatic conditions and rye weeds. It can deservedly displace wheat and barley and can be an alternative because of its soil-tightness, disease resistance and early harvest, which guarantees better yields. In recent years, triticale has been sought and preferred by a large number of farmers. This is one of the reasons why we recommend a triticale cultivation study in these regions. Triticale is a winter-resistant and cold-

resistant winter cereal crop. It does not tolerate thick snow cover, as well as high temperatures during flowering. It is not demanding on the soil. Due to its powerful bearded root system, triticale succeeds where no other crops can be grown. It is used mainly for grain production of dietary bread, concentrated feed for farm animals and a protein-rich green mass.

The relevant qualitative indicators of arable crops are to be reported and studied.

In the region of the Eastern Rhodopes, there are objective prerequisites for the development of olive, walnut and almond production, since the environmental factors are in a favorable combination with the biological characteristics of the three crops. The increased interest in walnuts and almonds is due to the following advantages: their fruits are highly stored, easy to transport, they can be traded at the most economical time, have a high price and are always a sought after item on the world market.

Walnut is grown for both fruit and wood. It can take its place in forest areas, in mixed small-sized plantations for family purposes and as single-species plantations for production purposes.

Almond grafting has indisputable environmental benefits because it does not form shoots and eliminates the need to use chemical agents to remove them. The more powerful and deeply penetrating root system copes better with the lack of moisture, allowing cultivation even under irrigation conditions.

The use of peach or wild plum as a substrate significantly alters the requirements of the almond to soil conditions and it can successfully grow on poorer, even rocky soils; ie areas where almond varieties cannot be grown on their own root. Olive trees are resistant to drought and disease. Their root system is durable and able to regenerate the tree, even when the trunk is frozen, burnt or cut off. The listed benefits of olive, walnut and almond graft define them as suitable fruit species and for desolate, poorly cultivated, sloping lands in different regions of the Eastern Rhodopes. In agri-environment, olives, walnuts and almonds have certain advantages over other fruit species:

\* well-maintained gardens of these species are productive up to the age of 60;

\* comparatively less care is needed during their cultivation - later pruning is applied, the harvesting of the fruits is relatively easy, less affected by diseases and pests, production processes are subject to mechanization; the olive can take places where the late spring frosts damage some fruit species.

Kardzhali municipality is located in the Ardin sub-region of the Eastern Rhodopes region in the southeastern part of Bulgaria. The relief is low-lying and hilly. Its diversity is intensified by the erosion of the rivers that form the modern maze of ridges and complex valley network. The most widespread soil differences are shallow leached cinnamon forest and undeveloped soils. The municipality is in the Eastern Rhodopes climate region, influenced by warm Mediterranean influence. The winter is relatively mild. Summer is sunny and hot, with maximums up to 40°C. The average annual temperature ranges from 11-13°C. The annual temperature sum for the growing season is about 3300 - 4000°C. Annual rainfall is 700-800 mm. Due to the highly eroded and sloping areas, which are unable to hold the autumn and winter rainfall, the moisture of the crops is not good. The deficit in the atmospheric humidity balance is about 370 mm.

Annual and perennial plants of the species einkorn wheat, buckwheat, soybean, rapeseed, sorghum, flax, walnut and almonds are planted on the territory of Kardjali Municipality.

On an area of two acres was made plowing of 50-60 cm and 54 trees were planted according to a single 8 x 8m methodology for walnut and 5.5 x 5.5m for almonds. All the requirements of the agricultural practice for field testing have been met. In a field survey in November, nearly 100% of fruit trees were intercepted. Moisture in the area is close to the norm for the month and no additional waterings have been made. No damage was reported from pests (diseases and pests). This trend is also maintained in the field survey in December. Apparently the plants are in very good condition. In January, due to prolonged freezing nighttime

temperatures (-5; -10°C), frostbite and death of some trees were observed. 7-8% of walnuts are completely killed, 5% are blackened, and the remaining 80-87% are visibly fresh, with a typical bark color but without development. Observations on the experimental field continue. In the region of the Eastern Rhodopes there are prerequisites for the development of walnut and almond production. The increased interest in walnuts and almonds is due to the following advantages: their fruits are highly stored, easy to transport, and can be traded at the most economical time. The external market is virtually unlimited. There is also a real demand in the country, which is satisfied with the import and own production.

In Bulgaria there are no traditions in the production of einkorn wheat (spelled), but the experience so far shows that its yields are significantly lower than other wheat. The yields of 120 kg were realized from acres, which shows that spelled can be an alternative to wheat and other cereals in the region. Its biggest advantage is that its species is preserved and that it makes it stable - it does not become ill and does not require pesticides and herbicides to be grown. There is an interest on the part of the bread makers to buy spelled flour to be used for the production of dietary bread. The main reason for the lack of sufficient supply of spelled on the market is the time-honored tradition of growing this crop and the lack of sufficient seeds of high-yielding varieties.

Flax is one of the possibilities for proper crop rotation with potatoes. The most suitable areas for these two crops overlap. Flax flax is a cool climate plant. It is water-loving to phenophase flowering, but then its water requirements are very low. It has a poorly developed root system and requires soils with easily digestible nutrients. Heavy, clay, swampy and acidic soils are unsuitable.

Buckwheat is a valuable food plant that is grown because of seeds that are highly nutritious and have remarkable taste. Grain processing waste is a good concentrated feed for pets. In green, its stems and leaves have significant feed value and can be used as livestock feed. The dried stalks are used to produce paper, and when burned they produce ash containing a large amount of potassium that can be used for fertilizer. Buckwheat is also a valuable honey plant with a yield of about 60 kg of honey per hectare of buckwheat. Buckwheat colors are characterized by the phenomenon of heterostyles - in some specimens the stalk is short and the stamens are longer than it, while in others the opposite is true. This difference between plants provides a more correct and full cross-pollination, and with a certain ratio of specimens with long and short stems, an increase in yield is obtained. Buckwheat is extremely suitable for cultivation in Bulgaria and gives a very good opportunity to receive additional income from the same area as a second crop. The positive thing about the crop is the rapid and powerful development of the plants, thanks to which it successfully suppresses weeds. After growing buckwheat, the agrophysical properties of the soil are greatly improved as it is able to absorb nutrients from hard-to-reach compounds.

The yields of the other annual crops studied are 96.50 kg/ha for soybeans, 115.7 kg/ha for rapeseed, 193 kg/ha for sorghum and 85 kg/ha for flax. The data obtained suggest that the crops under study can be grown as alternative crops of potatoes and tobacco.

## CONCLUSIONS

The fields that overcame the unfavorable climatic conditions with the least damage to the trees were reported in the municipality of Ivaylovgrad, where higher yields were obtained than the respective annual crops studied.

Of all 13 crops with the highest development and high yields were found in spelled, triticale, safflower, miscanthus, olives and almonds, while yields of hemp, flax, rapeseed, soybean, sorghum and buckwheat were unsatisfactory.

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