# KAPITEL 14 / *CHAPTER 14* [14]
# CHARACTERS OF GROWING THE FENUGREEK GREENS (TRIGONELLA FOENUM-GRAECUM) FOR SPICES

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## Introduction.

Vegetable growing in Ukraine, despite financial problems is developing rapidly. There remain unsolved problems, among which such as insufficient species and varietal diversity of vegetable crops, low productivity and quality of vegetable products as well.

Solutions to the problems of providing food to the World's population are actual. Moreover, products should be balanced in terms of all nutrients - proteins, fats, carbohydrates and vitamins. So far, no ideal variety has been created in the world in terms of the balanced content of nutrients. There is a significant deficiency in humans with the provision of protein, both of plant and animal origin. At the same time, food products must be ecologically safe.

Vegetable plants are characterized by a large variety - fruit, cabbage, green, root, bulb, flower, stem, etc. Among them, leguminous crops (*Fabaceae*) are noted as valuable, as a cheap and important source of protein, which is very poor in the modern human diet. A small number of species from the Fabaceae family are grown in Ukraine today. These are, first of all, vegetable types of beans, peas and, very rarely, beans [8].

However, the global diversity of cultivated leguminous vegetable plants is very significant and includes more than 45 of them: broad bean (*Phaseolus coccineus*) and lima bean (*Phaseolus lunatus*), sugar pea, winged pea (*Lotus tetragonolobus*), lablab bean (*Dolichos lablab*), soybean vegetable (*Glycine max*), asparagus bean (*Vigna unguiculata*), fenugreek (*Trigonella foenum-graecum*) and many others [6,8,10]. For these plants, no domestic varieties have been created in Ukraine, and vegetable growers widely grow local forms. For these species, practically (except for peas and beans) the technologies for their cultivation have not been developed, both for one-time collection and for the creation of a logistic system for the markets and supermarket [10].

Legumes (*Fabaceae*) have high nutritional properties. They are valued for the content of proteins and vitamins that are easily accessible to humans. Leguminous vegetable products accumulate all amino acids, mineral salts of iron, potassium, calcium, and phosphorus necessary for humans. Protein deficiency has a very negative

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effect on human health. So, according to Ilchuk M.M. (2003) more than 33 million people in Ukraine have a protein deficiency and 12 million - fats and carbohydrates [6]. A person consumes more protein with bread products - an average of 34.3%. However, the daily consumption of protein per person is 85.9 g for the norm of 90 g. Therefore, the production of leguminous vegetable crops can decide the protein deficiency of the population of Ukraine.

Among leguminous vegetable plants, there is one plant from which it can successfully obtain spices called "mushroom herb". Different types of fenugreek (*Trigonella foenum-graecum*) give an unsurpassed mushroom aroma. Varietal diversity of local forms in Ukraine is quite significant. Often, fenugreek is grown in villages to make charm bouquets for the national holydays, without knowing the main properties of the culture. Fenugreek bouquets smell like dried mushrooms. At the same time, local samples isn't collected in a collection and isn't systematized [6,8,10].

The main way of implementing fenugreek cultivation technology is the introduction of species to certain production conditions. Among the unexplored technological elements is the creation of a conveyor culture. Therefore, there is a problem of the influence of sowing dates and plant density on the growth and development of fenugreek kinds to expand the legume species diversity of vegetable crops.

## 14.1. Fenugreek growth capacity, plant's development and perspectives in Ukraine.

Fenugreek is one of the ancient medicinal plants. The ancient Egyptians used this plant as a vegetable, and its seeds were part of the spices they used for embalming. Fenugreek was used in ancient Egypt to treat wounds, inflammation, burns, and to promote childbirth, and with honey, it was used to treat depression, diabetes, and rickets.

The homeland of fenugreek is considered to be the eastern part of the Mediterranean. Widespread and the greatest diversity of its kinds is noted in Asia and Central Asia. This plant has gained worldwide recognition and is actively cultivated in many countries.

Two types of fenugreek are grown in Ukraine: hay (Greek hay, hay fenugreek or shambala - *Trigonella foenum graecum L.*) and blue (trigonella coerulea (Desr.) Ser.). The area of distribution is very wide from the Canary Islands in the west to the Far East [1,4,9]. Despite drought resistance, salt resistance and ultra-early ripening,

other types of fenugreek (Yemenian - *subsp. jemenensis*, sword-like (var. *gladiatum*), scalloped, Australian) are unknown in Ukraine [7].

Fenugreek belongs to the Bean family (*Fabaceae*). Common fenugreek (*Trigonella foenum-graecum L.*) and blue fenugreek (*Trigonella caerulea L.*) are the most common in culture. Common names of fenugreek are also known as fenugreek, gunba, mushroom grass, shambala, helba, camel grass, etc.

One-year kinds include hay fever (Greek hay, hay fenugreek or shambala) (*Trigonella foenum graecum L.*). They are grown in culture in Armenia, Azerbaijan, Central Asia, and in the Mediterranean countries. It is characterized by high drought resistance, undemanding to growing conditions, yields seeds in different years and is characterized by a short growing season [2,3].

The specific Latin name of fenugreek comes from "foenum-graecum" - "Greek hay", the plant is also known by the names fenugreek, shambala, helba, camel grass.

Hay fenugreek isn't fussy, although sunny places with non-acidic soil are more suitable. The best culture before it is potato, early cereals and vegetable crops, for example, cucumber or tomato, under which organic fertilizers were applied. Fenugreek seeds are sown 1.5 cm into the soil, in rows with a row width of up to 50 cm. After sowing, the soil is rolled.

Fenugreek seeds begin to germinate at +10°C, but mass shoots appear at +20-25°C. In the phase of two leaves, the sprouts are thinned. The distance between neighboring plants is about 7-10 cm. The next thinning is carried out during the appearance of lateral shoots, the distance between plants should be at least 15-20 cm. To increase the yield of fenugreek seeds during the period of fruit setting, it is necessary to feed the plants with phosphorus-potassium fertilizers. Fenugreek blooms in June, the fruits begin to ripen in August-September. After appearance of ovary and beans irrigation must be reduced and completely stopped as the beans ripen. Harvesting of fenugreek begins after the beans have browned. Not only fenugreek seeds are collected, but also the tops of the inflorescences, which are later dried and ground.

Fenugreek plants are characterized by high drought resistance, undemanding to growing conditions and short growing season. It belongs to the legume family so it enrichs the soil with nitrogen. Plants are resistant to diseases and pests. It is a good crops in rotation for all crops.

Along with Fenugreek, blue Fenugreek (Trigonella coerulea (Desr.)) is also grown. It is an annual plant. According to experts, blue fenugreek is a wild form of cultivated plants that combine the features of two botanical kinds - fenugreek (Trigonella) and fennel (Melilotus). Other names of this plant are: dark blue gourd, blue gourd, Egyptian gourd, dark blue goat's shamrock. In English-language sources it

may be found under the name “blue fenugreek”, and in Switzerland it is usually called Schabzigerklee, because it is used to prepare the famous Schabziger cheese (Sap Sago).

This type of fenugreek can be found in the Alps, in the mountains of Eastern and Southeastern Europe, in the Caucasus and in the Crimea. Blue fenugreek in its wild form grows on littered places, roadsides, fields, in thickets of bushes.

Blue fenugreek belongs to fodder plants. It is willingly eaten by farm animals, but due to low productivity on an industrial scale, it is not used as a fodder plant. It’s a good honey bee plants.

The culture is unpretentious to growing conditions. The most suitable for all leguminous crops are fertile, weed-free soils with a neutral reaction of the soil solution. It requires well sun’s lightening and generously fertilized areas. It grows quickly, besides, it enriches the soil with nitrogen, as it belongs to the legume family. It is a good crop for all crops in rotation. Diseases and pests do not affect the Fenugreek.

The culture is cold-resistant, so it is better to sow the seeds in the second half of April. The optimal methods of sowing are wide-row (45×15, 60×15 cm) and strip (20+50)×15 cm. Sowing depth is 1.5-2.0 cm. After sow the sowing is rolled, preferably mulched with peat or humus. Shoots appear on the 8-10th day. Crops are thinned once, leaving 15 cm between plants.

Fenugreek is grown as an aromatic-tasting, fodder and cider crop. A crushed mixture of inflorescences and seeds of the plant is a spice that gives food, depending on the amount, the smell of nuts or dried mushrooms, so this mixture is often used as a seasoning in cooking and in vegetable preparations. The seasoning has a delicious aroma and exquisite taste.

From the dried fruits of the blue fenugreek, the famous Georgian seasoning food named "Utsho-suneli" is prepared, which is a homogeneous loose powder of greenish-gray or olive-green color with a strong characteristic refreshing astringent aroma and sweetish taste with slight bitterness.

Whole blue fenugreek seeds are usually sold in bean’s shells. Beans of high quality should be full, uniform in color, with a strong characteristic smell, and should not contain extraneous impurities and large residues of other plant parts. They are stored for up to 2 years in a hermetically sealed container.

Fenugreek plants in fresh form don’t have a pronounced intense smell, which is cleared only after drying during storage. Dried and crushed into powder, the young tops of the shoots during the flowering period are used for meat dishes and in cheese making. In addition, crushed seeds smell like dried mushrooms and are used for flavoring in cooking and the bakery industry. Fenugreek seeds are indispensable for

preparing many dishes. In addition, fenugreek seeds are used for seedlings. Salads are prepared from young plants, which are very useful for health due to the content of biologically active substances.

The green mass of fenugreek, collected during mass flowering until the moment of fruit formation, contains a significant amount of substances from which coumarin is formed during the drying process, which is the main component of essential oil.

It is also included in the mixture of hops-suneli (Georgian mixture of dried spices), curry and Chaman mixture, which is used to cover dried meat tenderloin - basturma. In the USA, fenugreek is used to flavor rum and maple syrup, and is sometimes added to dough.

Fenugreek is an ingredient in curry and many other spicy mixtures and culinary recipes of Eastern especially Indian and Pakistani kitchen. There is also a lot of fenugreek in African cooking, especially Ethiopian. Ethiopian cooks use it to prepare a spicy clarified oil, and also include it in a mixture of Berber spices.

Fenugreek also has medicinal properties, as it contains many vitamins and other biologically active substances necessary for the human. Fenugreek increases immunity, stimulates appetite, has anthelmintic properties. A decoction or tincture of its seeds helps to treat chronic cough, liver diseases, gout, diabetes, and has a diuretic effect. Fenugreek is especially valuable for the treatment of anemia and neurological problem.

Fenugreek is widely used in traditional medicine of many countries, in particular, in Chinese, Indian, and Western European. In a number of countries, the seeds of this plant are part of combined medicinal products that have diuretic, laxative, anti-inflammatory, anabolic and antisclerotic effects.

Fenugreek has a tonic, tonic, restorative, soothing, diuretic effect. At the same time, it has an antispasmodic, anti-inflammatory, expectorant and antioxidant effect on the human body, stimulates sweating and, as a result, is an antipyretic. Removes toxins and allergens through the lymphatic system, lowers cholesterol in the blood and blood pressure, increases hemoglobin in the blood (as a source of iron), improves intestinal peristalsis, strengthens uterine contractions, and is also an aphrodisiac [5] .

Fenugreek seeds collected in the phase of biological maturity are used as medicinal raw materials. They contain alkaloids (trigonelline), essential oils, steroids, flavonoids, coumarins, polysugars, proteins (amino acids: alanine, arginine, glycine, methionine, etc.), carbohydrates (45-60%), vitamins (A, C, B, P), mineral salts (Ca, Mg, P, Fe, K, S, etc.). Polyphenols of this plant have pronounced antioxidant and antibacterial properties [2,5].

Fenugreek seeds, as was proven by a group of scientists, have a gastroprotective effect. Fungicidal, antiviral and antimicrobial activity is also manifested in the seeds.

An important role is assigned to steroidal saponins of fenugreek in increasing the resistance of plants to environmental stressors and phytopathogens.

Modern studies have shown that fenugreek is rich in protein and carbohydrates, and also contains potassium, phosphorus, magnesium, iron, calcium, vitamins A, C, B1, B2, PP, folic acid; trace elements are also present in it: vanadium, manganese, chromium. According to its chemical composition, fenugreek is very similar to fish oil.

Today, this culture is included in the official pharmacopoeia of many countries of the world, in particular, the British herbal pharmacopoeia [5,9]. Fenugreek seeds are part of many combined medicines that have diuretic, laxative, anti-inflammatory, hypoglycemic effect and memory's problems.

Fenugreek seeds contain the following substances: trigonelline alkaloid (0.3%), vitamins A, C, B1, B2, B3 (nicotinic acid, vitamin PP) - 3.5-18 mg\%, B6 (pyridoxine), B9 (folic acid), rutin (vitamin P), steroidal saponins and phytosterols (diosgenin, yamogenin, gitogenin, tigogenin) and 51 glycosides (dioscin and jamoscin), flavonoids, mucous (up to 30%) and bitter substances, essential oils (6%), proteins, tannins, phosphorus, iron, potassium, magnesium, calcium [5].

Fenugreek attracted the attention of world scientists, first of all, as a possible source of steroid saponins and diosgenin, which is one of the most important starting products of the synthesis of cortisone and its analogs.

At the moment, domestic pharmacy is experiencing an acute shortage of medicinal plant raw materials containing steroidal saponins. The main sources of materials for the production of steroids are Dioscore caucasus, Japanese and deltoid, nightshade, yarrow, etc. However, thшi materials obtained from these cultures are far from satisfying modern needs. The introduction into production of fenugreek, as well as some other types of plants, which in other countries are grown on large areas and are widely used for food and medicinal purposes, would make it possible to ensure a reliable raw material base and rational preservation of the resources of many wild and endangered plants.

They are used in the form of tincture, decoction, powder, paste. Fenugreek contains up to 1.34% of the amount of steroidal saponins (diosgenin, tigogenin, yamogenin), mucilage, protein, folic acid, mineral salts, starch, sugar, essential oil, enzymes. Its seeds are rich in potassium, phosphorus, magnesium, iron, calcium, vitamins (A, C, B1, B2, PP), contain all the essential amino acids our body needs, and help digest proteins.

The need to introduce fenugreek into daily diets as a biologically active supplement, as well as the use of this plant for the production of healthy, dietary and functional food products, becomes obvious.

## 14.2. The influence of sowing dates on the growth and development of fenugreek plants

The research was conducted during 2012-2014 at the collection site of the department of vegetable growing and Protected Cultivated in the National University of Life and Environmental Science of Ukraine in the forest-steppe zone of Ukraine on sod-medium soils.

The investigations was done according to the method of two-factor experiments [6,8,10]. The subjects of the research were Fenugreek species - blue fenugreek (*Trigonella caerulea L.*) and hay fever hay fenugreek (*Trigonella foenum graecum L.*). and sowing dates. The early spring sowing period (10.04) was taken as control. Repetition - three times with randomization. The registered area of the site was 5 $m^2$. Calculations were carried out on 30 plants - 10 from each repetition. The technology of growing Fenugreek species is generally accepted in production conditions for leguminous crops. The seeding scheme was 45×15 cm. The depth of seed's sowing was 1.0-1.5 cm for the blue fenugreek, 2-3 cm for the dark blue fenugreek.

Sowing of both kinds of Fenugreek was been simultaneously in four periods:

- early spring - II-III decade of April (10.04. - 2012, 24.04. - 2013, 10.04. - 2014);
- late spring 1 term – 3rd decade of April - 1st decade of May (25.04. - 2012, 08.05. - 2013, 29.04. - 2014);
- late spring 2-nd term – 2-nd decade of May (15.05. - 2012, 17.05. - 2013, 14.05. - 2014);
- summer - 1st decade of June (10.06. - 2012, 04.06. - 2013, 05.06. - 2014). The sowing of seeds for the early spring and first late spring terms in 2013 had to be carried out later due to the prolonged cold spring. Control variant was early spring sowing period (II-III decade of April).

Fenugreek was grown according to the technology that makes it possible to maximize the productivity of the crop under the conditions of compliance with the requirements of cultivation at each stage of organogenesis. The prediction crop was the potato. After clearing the field, disking was carried out to a depth of 6-8 cm and repeated after 10-15 days in order to control weeds. Plowing was been to a depth of 22-25 cm. There was phosphorus and potassium fertilizers were applied at the rate of 60 kg/ha before main plowing.

In the spring, harrowing was been in order to seal moisture in the soil. Pre-sowing cultivation was been to the depth of seed sowing with application of ammonium nitrate to the soil at the rate of 60 kg/ha of the active substance. After sowing, the soil was rolled. During the growing season, inter-row treatments were done manually. The first

time, the soil was loosened in the phase of full emergence to a depth of 5 cm, the next - until the places between rows closed to a depth of 6-8 cm.

As we can see, during the research, all necessary elements of fenugreek growing technology were observed in order to ensure optimal growth and development of plants.

According to phenological researches, it was established that the growth and development of fenugreek plants depended on the sowing date. On average, over the three years of research, fenugreek species with the shortest duration of the growing season, 36-37 days.

Fenugreek species were characterized by a more developed vegetative mass during the early spring sowing periods and the late spring 1-st sowing period. To obtain the green mass of fenugreek plants in the conveyor, the early spring sowing dates and the late spring 1 season were more suitable, during which the plant height and the number of shoots of blue fenugreek were 62.0-75.9 cm and 3.7-5.1 plants, respectively. In variant with hay fenugreek - 32.7-34.5 cm and 6.0-7.1 plants with a greater thickness of the stem near the root neck.

It was established that the studied fenugreek species differed in economic and valuable indicators. Productivity and average yield of green mass of plants were significantly influenced by factor B (sowing period). A significant difference was established between the control and late spring (2 terms) and summer terms of sowing. No significant difference between fenugreek species in economic and valuable characteristics was found.

Productivity of plants of affected their average yield of green mass. Thus, a higher yield of green mass was obtained in fenugreek species using early spring sowing periods, which amounted to 6.9-9.3 t/ha. The significantly lower difference between the control was not found in species for 1 late spring sowing period. The average productivity of the green mass of the species during this period was 5.7-7.3 t/ha. During other sowing periods, the average yield of green mass in species was significantly lower by 2.9-8.1 t/ha. This difference was found to be smaller in blue fenugreek by 42-84%.

The lower yield of green mass of blue fenugreek was obtained during the summer sowing period, which averaged 1.1 t/ha over three years (Fig. 1). The yield was found to be 84% lower in the species compared to the control. With each subsequent sowing term, the yield of green mass decreased sharply due to the less developed vegetative apparatus of plants.

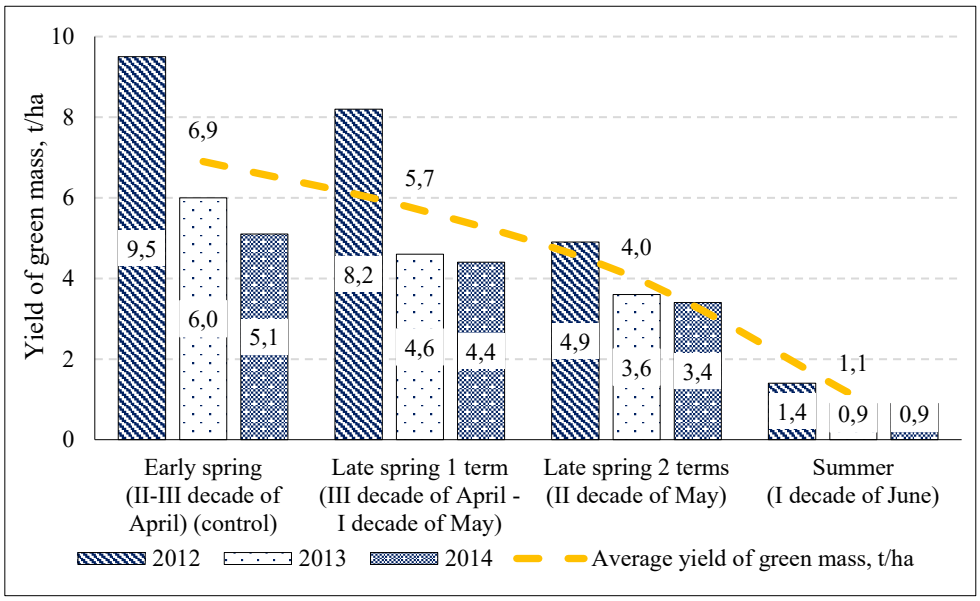


**Fig. 1 – The dynamics of yield's formation of blue fenugreek's green mass**

A higher yield of green mass was obtained from fenugreek at all sowing times. At the same time, the highest yield of 9.3 t/ha was obtained during the early spring sowing period. The same regularity has been established for fenugreek as for blue fenugreek. With each subsequent sowing period, the productivity decreased sharply and during the summer period it was the lowest and amounted to 1.2 t/ha, which is 87% less than the control (Fig. 2).

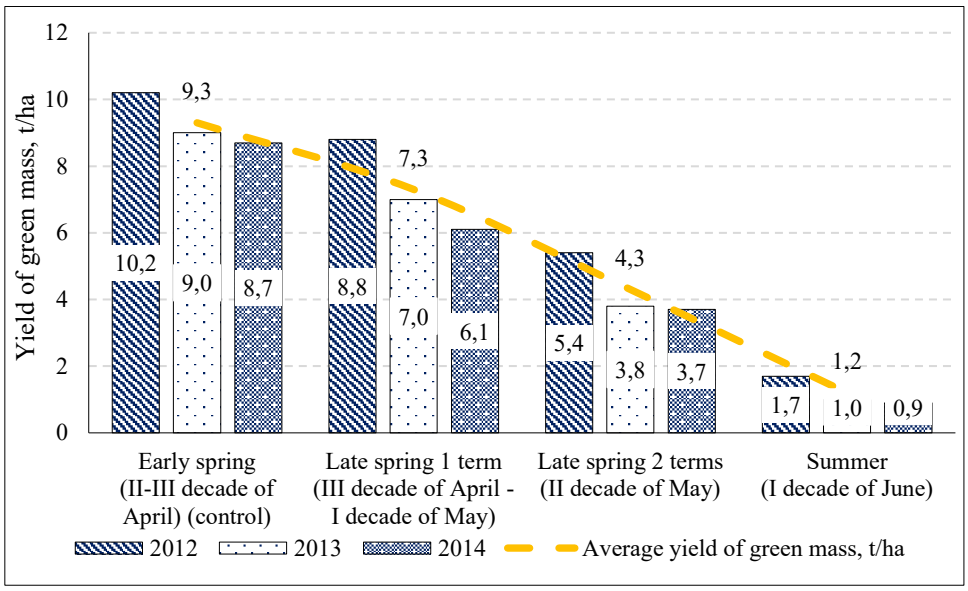


**Fig. 2 – Dynamics of harvest's formation (green mass) of fenugreek**

The lower harvest of the green mass of fenugreek plants is due to the less developed vegetative mass of plants during the summer sowing period. High air and soil temperatures contributed to the faster passage of all phases of plant growth and

development, but to a lower increase in above-ground mass in fenugreek species. Therefore, exactly 2 late spring and summer sowing terms are not suitable for growing fenugreek in the Forest Steppe of Ukraine.

For food needs, the dried upper part of the plant, ground into a powder, is used, so this prompted drying the green mass of fenugreek species and determining the economic and valuable indicators of dried products.

According to the research results, it was established that the harvest of dry mass of fenugreek species depended significantly on the sowing time (factor B). The dry mass yield of fenugreek species was influenced by the moisture loss factor. Thus, this coefficient turned out to be the lowest in species during the summer sowing period and was 1.5-1.8. This is caused by high temperatures in the summer and loss of turgor due to intensive respiration by plants. The highest coefficients of moisture loss were found in fenugreek species during the early spring sowing period (6.5-6.8).

This indicator is lower in blue fenugreek from 6.5 to 1.8, which is 0.2-0.3 less compared to hay fenugreek.

The high moisture content in plants during the early spring sowing period affected the loss of the dry weight crop. Thus, in blue fenugreek, the highest average yield of dry mass over three years was obtained during the early spring and late spring sowing periods, which was 1.1-1.2 t/ha (Fig. 3). Moreover, favorable conditions for obtaining dry mass of plants with the lowest coefficient of moisture loss emerged in 2012 with high humidity and moderate temperatures at the first stages of growth and a high sum of active temperatures in summer during the formation of generative organs.

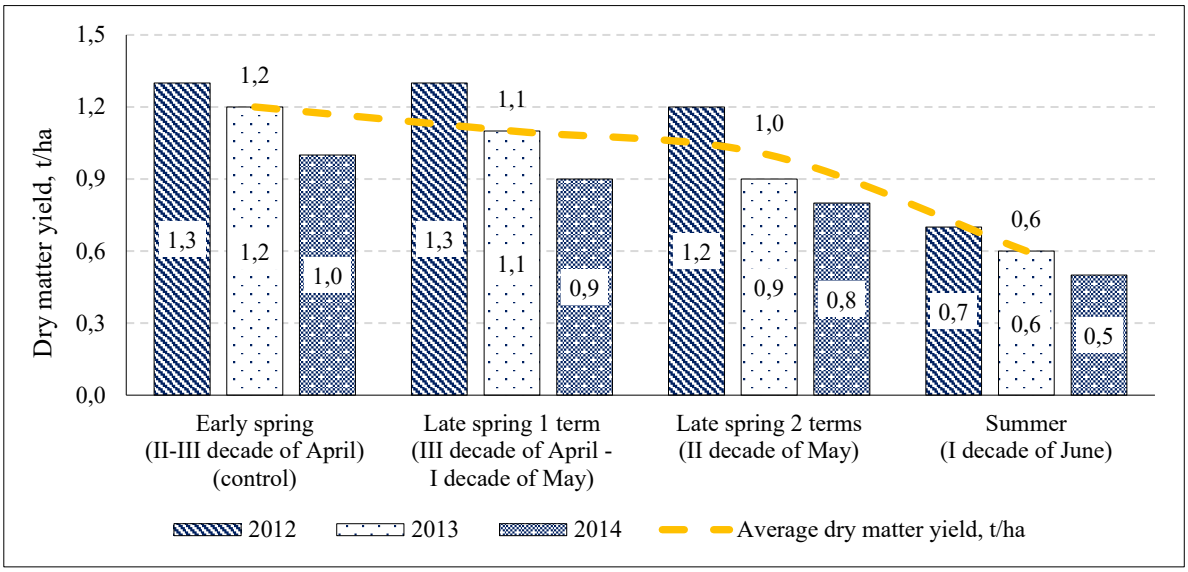


**Fig. 3 – The dynamics of the harvest of dry mass of blue fenugreek at different sowing times**

The low dry mass yield of blue fenugreek was obtained during the summer sowing period in an average of three years of research (0.6 t/ha) due to the lowest yield of green mass, despite the lower rate of moisture loss. The yield of dry mass during summer sowing decreased by 50% compared to the control. The same trend was observed in hay fenugreek. At the same time, the yield of fenugreek was higher by 0.2 t/ha compared to other species. No significant difference was found between the yield of dry mass during early spring and late spring sowing periods, which averaged 0.8-1.1 t/ha for the species over three years (Fig. 4).

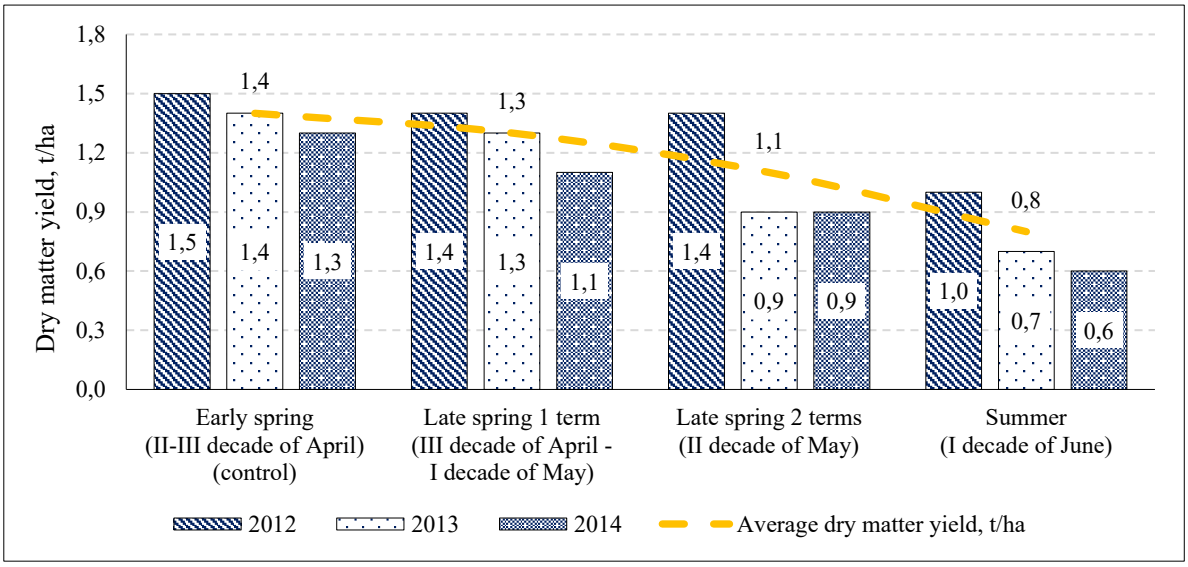


**Fig. 4 – The dynamics of the yield of the dry mass of fenugreek**

The summer sowing period was unsuitable for the cultivation of fenugreek species, during which the lowest yield of green and dry mass of plants was obtained. This is due to the formation of lower plant height, a small number of shoots of species due to intensive growth and rapid passage of all phases of growth and development. Moreover, during summer sowing, seedlings were obtained faster, but less developed root system and vegetative mass of plants of fenugreek species were formed. Fenugreek species have a wide range of variability in terms of morphological and economic value characteristics, which affected their seed productivity. Fenugreek species are characterized by a high productivity of dry seeds during the early spring (II-III decade of April) sowing dates, during which the yield of dry seeds of blue fenugreek was 0.4 t/ha, of fenugreek - 2.0 t/ha with a weight of 1000 seeds, respectively 0 ,71 and 9.7 g.

Fenugreek species in early spring (II-III decade of April) are characterized by high quality indicators of green mass and the 1st late spring (III decade of April-I decade of May) sowing dates with the content of dry matter in fresh produce 12.4-28.4%, total

sugars 2.5-5.0% and vitamin C - 38.0- 51.8 mg/100 g. According to the content of basic biochemical indicators in fresh leaves, fenugreek stood out among the studied species.

## 14.3. The influence of plant density on the formation of economic and valuable capacities of fenugreek

The research was conducted during 2012-2014 at the collection site of the department of vegetable growing and Protected Cultivated in the National University of Life and Environmental Science of Ukraine in the forest-steppe zone of Ukraine on sod-medium soils.

The investigations was done according to the method of two-factor experiments [6,8,10]. The subjects of the research were Fenugreek species - blue fenugreek (*Trigonella caerulea L.*) and hay fever hay fenugreek (*Trigonella foenum graecum L.*). and sowing dates.

Hay fenugreek was studied under different sowing schemes: 45×5 (444 thousand plants\ha), 45×10 (222 thousand plants\ha), 45×15 (148 thousand plants\ha - control), 45×20 cm (111 thousand plants). Repetition were three times with randomization. Sown during the early spring sowing period (April 10, 2014, April 12, 2015, April 8, 2016). The area of the researches was 5 $m^2$. Calculations were carried out on 30 plants - 10 from each repetition. The technology of growing fenugreek is generally accepted in production conditions for leguminous crops. The depth of seed's sowing of hay Fenugreek was 2-3 cm.

It was established that the growth and development of fenugreek plants depended on the sowing scheme. The most early-ripening plants were the plants with a plant density of 444,000 plants/ha (45×5 cm) with the shortest duration of the phenological phases of growth and development and a growing season of 55 days.

Analyzing the biometric indicators of fenugreek in an average of three years under different sowing schemes, it should be noted that plants on thinned sowings (45×20 cm) had a more developed vegetative mass (Table 1). Moreover, a significant mathematical difference according to morphological features was established. As the density increases in the species, the height of the plants decreases. In fenugreek, this difference was 14.9 cm. The same trend was observed for other morphological indicators in the species.

Fenugreek hay was characterized by a more developed vegetative mass on sparse sowings of 111,000 units/ha (45×20 cm). Crops with a plant density of 111-148 thousand plants/ha (45×15, 45×20 cm) were more suitable for obtaining green mass of

**Table 1 – Characteristics of morphological capacities of fenugreek plants during harvest setting under different sowing schemes (average for 2014-2016)**

| Variants | Plant's height, cm | Shoot's quantity, things | The thickness of the stem in the root neck, mm |
|---|---|---|---|
| 45 × 5 | 24,5 | 4,1 | 7,0 |
| 45 × 10 | 32,7 | 6,8 | 10,8 |
| 45 ×15 (control) | 34,5 | 7,1 | 11,0 |
| 45 × 20 | 39,4 | 9,3 | 11,6 |
| $LSD_{05}$ | 2,8 | 0,7 | 0,2 |

culture plants, in which the height of plants and the number of shoots were 34.5-39.4 cm, respectively and 7.1-9.3 plants with a stem thickness near the root neck of 11.0-11.6 mm.

It was established that fenugreek differed in terms of economic and valuable indicators depending on the density of crops (Table 2). The productivity and average yield of the green mass of plants was significantly influenced by the sowing scheme. In addition, a significant difference in plant productivity was established between the control and the 45×5 cm sowing scheme.

On the control variant with a plant density of 148,000 plants/ha (45×15 cm), the productivity of fenugreek plants was higher and amounted to 69.0 g. The yield was significantly lower on sparse Fenugreek fields (45×5, 45×10 cm), the productivity of fenugreek plants decreased and amounted to 29.0-59.1 g.

Productivity of fenugreek plants affected its average yield of green mass. The significantly higher harvest of green mass was obtained in dark blue Fenugreek with plant density of 222,000 plants/ha (45×10 cm), which averaged 13.1 t/ha over three years. At the same time, a significantly lower difference between the control was not found under the 45 × 5 cm sowing scheme. The average yield of the green mass of the species under this sowing scheme was 12.9 t/ha. On thinned crops density (45×20 cm), the average yield of green mass in the species was significantly lower by 4.3 t/ha, which is 35% less than the control.

The lower harvest of the green mass of fenugreek plants is caused by a smaller number of plants. In sparsely planted crops, plants were formed with a better developed aerial foliage, but the smaller number of plants resulted in lower harvest. At the same time, on the plants with density 444,000 plants/ha, the growth of above-ground mass

**Table 2 – Economically valuable indicators of Fenugreek's green mass for the different sowing schemes (average for 2014-2016)**

| Variants of investigation | Productivity, g | Harvest of green mass by year, t/ha | | | Average harvest of green mass, t/ha | Harvest growth (average of three years) | |
|---|---|---|---|---|---|---|---|
| | | 2014 | 2015 | 2016 | | т/га | % |
| 45 × 5 | 29,0 | 12,4 | 12,2 | 14,1 | 12,9 | +2,7 | +26 |
| 45 × 10 | 59,1 | 13,4 | 12,9 | 13,0 | 13,1 | +2,9 | +28 |
| 45 ×15 (control) | 69,0 | 10,4 | 9,7 | 10,6 | 10,2 | 0 | 100 |
| 45 × 20 | 71,5 | 8,6 | 6,8 | 8,3 | 7,9 | -2,3 | -22 |
| $LSD_{05}$ | 8,2 | 1,2 | 1,1 | 0,8 | | | |

turned out to be smaller, although all phases of growth and development passed faster. Therefore, to use such sowing schemes as the 45×5, 45×15, 45×20 cm for fenugreek in the Forest Steppe of Ukraine isn't recommended.

Over the years of research, the lowest yield of green mass was established in 2015. This is due to insufficient rainfall from June to September. In particular, the drought was critical in July, which affected fenugreek productivity.

According to the research results, it was established that the yield of dry mass of fenugreek significantly depended on the sowing scheme (Table 3).

The dry mass harvest of variants was influenced by the moisture loss coefficient. This coefficient was the lowest for Fenugreek with the high plant's density (45×5 and 45×10 cm) and amounted to 6.4-6.5 cm. This is due to high temperatures crops and loss of turgor due to intensive plant respiration. The higher moisture loss coefficient was characterized by the culture under sparse sowing (45 × 15 (control) and 45 × 20 cm) and was 6.8, which affected the lower yield of dry mass. At the same time, over the years of research, the highest coefficient of moisture loss was obtained in 2016. This is due to an excessive amount of precipitation in May-June, during the growth of the vegetative mass of the crop.

**Table 3 – Economically valuable indicators of dry mass of Fenugreek hay under different sowing schemes (average for 2014-2016)**

| Variants of experiment | Average coefficient of moisture loss | Dry mass yield in year, t/ha | | | Average harvest Of dry mass, t/ha | Harvest dynamics | |
|---|---|---|---|---|---|---|---|
| | | 2014 | 2015 | 2016 | | t/ha | % |
| 45 × 5 | 6,4 | 2,5 | 1,8 | 1,7 | 2,0 | +0,2 | +11 |
| 45 × 10 | 6,5 | 1,5 | 2,3 | 2,2 | 2,0 | +0,2 | +11 |
| 45 ×15 (control) | 6,8 | 1,5 | 1,8 | 2,1 | 1,8 | 0 | 100 |
| 45 × 20 | 6,8 | 0,9 | 1,2 | 1,5 | 1,2 | -0,6 | -33 |
| $LSD_{05}$ | | 0,5 | 0,6 | 0,5 | | | |

The high moisture content affected the loss of the dry weight crop. Thus, in fenugreek, a higher dry mass yield was obtained with the 45 × 5 and 45 × 10 cm sowing schemes, which amounted to 2.0 t/ha, which is 0.2 t/ha more than the control. This yield was significant for culture in 2015-2016.

It was established that the plant density of 444,000 plants/ha (45 × 10 cm) had a positive effect on the seed productivity of the species. Although the low plant's density resulted in fewer beans per plant, they were larger and had more seeds. This contributed to an increase in the seed productivity of the species compared to other sowing schemes (Table 4).

Fenugreek plants formed a larger number of beans on thinned crops (45×20 cm), which amounted to 71.0 beans, which is 5.3 more control. This affected the high average productivity of plants (13.9 g). At the same time, the length of the beans and the number of seed-thinned crops (111 thousand/ha) were smaller and amounted to 14.5 cm and 18.7, respectively, which is 0.5 cm and 2.3 less control. Therefore, despite the greater mass of 1000 seeds for the 45 × 20 cm (10.5 g) sowing scheme, the lowest yield of ripe seeds was obtained in the species - 1.5 t/ha, which is 0.5 t/ha less than the control.

Both the weight of 1,000 seeds and plant productivity influenced the seeds' harvest of fenugreek plants. The culture formed large seeds with a mass of 1000 seeds

of 6.5-10.5 g, which was smaller in the variant with high plant density. The average yield of ripe seeds in the species was the highest in the variant with high plant density (45 × 5 cm). This is due to larger beans and a larger number of seeds in them, which affected the yield of ripe seeds, which under this scheme was found to be 2.9 t/ha. However, the seeds were smaller, with a weight of 1000 seeds of 6.5 g, which reduced its sowing properties. Therefore, the optimal plant density was set at 222,000 units/ha, at which the yield of ripe seeds averaged 2.4 t/ha over the years of research, which is 0.4 t/ha more than the control.

**Table 4 – Seed productivity of fenugreek for different sowing schemes (average for 2014-2016)**

| Variants | The number of beans per plant | Length of the bean, cm | The number of seeds in a bean | Average productivity, g | Harvest of ripe seeds, t/ha | Weight of 1000 seeds, g |
|---|---|---|---|---|---|---|
| 45 × 5 | 45,7 | 15,4 | 22,0 | 6,5 | 2,9 | 6,5 |
| 45 × 10 | 56,5 | 15,2 | 21,5 | 10,9 | 2,4 | 9,0 |
| 45 ×15 (control) | 65,7 | 15,0 | 21,0 | 13,3 | 2,0 | 9,7 |
| 45 × 20 | 71,0 | 14,5 | 18,7 | 13,9 | 1,5 | 10,5 |
| $LSD_{05}$ | 5,8 | 0,5 | 2,5 | 1,7 | 0,7 | 2,7 |

The low density of fenugreek plants reduced its seed productivity. Thus, under the sowing schemes of 45×15 and 45×20 cm, seed productivity decreased due to the formation of a smaller number of seeds in beans and was 1.5-2.0 t/ha. At the same time, the seeds at the lowest plant density (111-148 thousand pieces/ha) turned out to be larger, 9.7-10.5 g.

**Conclusions.**

1. To obtain a high yield of green mass of fenugreek species in the conveyor, it is better to use early spring (II-III decade of April) and late spring (III decade of April-I decade of May) sowing dates. Under these terms of sowing, a higher yield of green plant mass of 5.7-6.9 t/ha in blue fenugreek and 7.3-9.3 t/ha in dark blue fenugreek was established on average over three years of research.

2. It is promising to grow hay fenugreek during the early spring (II-III decade of April) and 1st late spring (III decade of April-I decade of May) sowing dates for which higher dry mass productivity (1.3 -1.4 t/ha).

3. The study of the influence of sowing dates on the growth and development of plants of fenugreek species makes it possible to single out hay fenugreek based on the main economic value indicators for its effective introduction into the production of spices called "mushroom herb".

4. For obtaining dried products, fenugreek with a plant density of 222-444 thousand plants/ha (45 × 5 and 45 × 10 cm) turned out to be highly productive, where a lower coefficient of moisture loss (6.4-6.5) and a higher yield of dry mass (2.0 t/ha).