AGRICULTURAL ACADEMY

SOFIA FRUIT GROWING INSTITUTE – PLOVDIV

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EFFICACY AND SELECTIVITY OF SOIL HERBICIDES IN LAVENDER (Lavandula angustifolia Mill.)

EXTENDED ABSTRACT

Of PhD Thesis for awarding educational and scientific degree

"Doctor"

Professional field: 6.2 Plant protection

Scientific specialty: "Herbology"

Supervisor: associate professor Ganka Baeva, PhD

Plovdiv, 2020

The dissertation contains 133 pages, 22 figures and 69 tables. The cited literature includes 147 sources, of which 106 in Cyrillic and 41 in Latin.

The defense of the dissertation will consist of ………………,at o' clock, in the conference hall in Fruit Growing Institute - Plovdiv. The specialized scientific jury is appointed by order № RD 05-327/09.11.2020

INTRODUCTION

Lavender - Lavandula angustifolia Mill. is one of the main essential oil crops for the conditions of Bulgaria. It is a semi-shrub plant of the family Lamiaceae.

It is grown mainly for the production of high quality essential oil, which is used in the perfumery, pharmaceutical industry and medicine (Yankulov, 2000). Lavender is grown mainly in the regions of Stara Zagora, Plovdiv, Varna and Shumen. In the period 1987-1997 there was a decline in lavender production. After 1998, the demand for essential oil on international markets increased. The interest in Bulgaria is growing and after 2008, the areas increase more than three times. The creation of plantations between 2012-2015 is intensive, when the total areas approach 7000 ha (Grebenicharski, 2016). Although crop yields are highly dependent on weather conditions in individual years, there is a clear increase in averages. In the last four years, they are in the range of 250-350 kg / da green mass, compared to an average of about 200 kg before 2013. This determines an increase in production, exceeding that in the areas. Thus, in 2015 almost 19,000 tons of green mass were harvested - four times more than in 2008. The increase in green mass productivity is mainly due to the spread of the crop on more fertile soils in Dobrogea and Thrace, where growth and formation the inflorescences are significantly more intense.

In recent years, the capacity for the production of essential oil has increased significantly - both with the expansion of existing and the construction of new distilleries. According to industry estimates, between 200 and 250 tons of oil are produced annually in the country.

Weed control is extremely important in the system of measures aimed at increasing the economic efficiency of growing lavender, to obtain high and lasting yields. This is one of the important agro-technical and economic problems for lavender production in our country.

So far, systematic studies on the possibilities for chemical control of weeds in lavender in our country have not been done. In the modern development of agriculture and the application of new industrial technologies, this problem is important, which required research in our conditions.

OBJECTIVE AND TASKS OF THE RESEARCH

Weeds have the ability to continuously adapt to the action of the applied herbicides and this requires testing active substances with different spectrum and mechanism of action in different crops.

The aim of this dissertation is to study the effect of the herbicides isoxaflutol, oxadiargyl, imazamox and flumioxazine on weeds in two varieties of lavender - Hemus and Jubilejna. This study is necessary for the future development of appropriate integrated weed control. To achieve this goal, the following tasks are set:

1. Determining the species composition and density of weeds in lavender plantations and establishing the effectiveness of the soil herbicides used against them.

2. Establishing the influence of the studied soil herbicides on the phenological development and physiological condition of lavender varieties.

3. Influence of herbicides on the economic indicators of lavender varieties.

4. Determination of the values of the main components of the essential oil of the lavender varieties, after the use of herbicides.

MATERIALS AND METHODS

1. Filed experiments

To achieve the goal and objectives of the study, in the period 2011-2015 in the experimental field of Institute for roses and aromatic plants – Kazanlak was conducted a field experiment with herbicides applied to lavender, including varieties "Jubilejna" and "Hemus". The herbicides isoxaflutol 750 g / kg (Merlin 750 VG), oxadiargyl 400 g / l (Raft 400 SK), imazamox 40 g / l (Pulsar 40), flumioxazine 500 g / kg (Pledge 50 VP), applied in two doses, were studied. . Herbicides are applied to the soil before the lavender vegetation.

1.1 Variants:

1. Control - untreated, without hoeing

Optimal dose

2. Isoxaflutol - 3.8 g / da
3. Oxadiargyl - 48 g / da
4. Imazamox - 6 g / da
5. Flumioxazine - 15 g / da

150% increased dose

6. Isoxaflutol - 5.7 g / da
7. Oxadiargyl - 72 g / da
8. Imazamox - 9 g / da
9. Flumioxazine - 22.5 g / da

1.2. Researched varieties of lavender the Hemus variety and the Jubilejna variety, entered in the national variety list of Bulgaria, were used in the study.

Lavender variety "Hemus" - the variety was created in 1973 in Institute for roses and aromatic plants - Kazanlak by the method of individual selection and branch selection.

The variety has rounded, tufted tufts. Its leaves are fresh green. Forms 450-500 flowering stems, which are erect, with strong slightly long stalks - an average of 15 cm. The class is concise, cylindrical, kitschy. The corolla leaves are light purple blue and the calyx is dark purple.

At the age of normal flowering, an average of 560 kg / da is obtained. The content of the essential oil is on average 1.76% or 10 kg of essential oil with 60% linalyl acetate are obtained per decare.


Lavender variety "Jubilejna" - The variety was created in 1988 in Institute for roses and aromatic plants – Kazanlak by the method of hybridization.

The plants are round, erect, with a collected habit. The inflorescences are erect with a length of about 22 cm. The calyx is colored half green, half purple, and the corolla is dark purple. The leaves are dark green.

According to the pace of development and flowering, the Jubilee variety is medium-flowering.

The yield of color is 554 kg / da, the content of essential oil - 2.86%, and the yield of essential oil is 15.7 kg / da with good quality and content of esters - linalyl acetate - 55-60%.


2. Biological research The following indicators were observed during the experiments.

2.1. Registration of the occurrence of the main phenological phases - beginning of vegetation, budding, flowering, ripening, second growth and end of vegetation.

2.2. Reporting of herbicidal activity and selectivity according to the 9-point EWRS system

Table 1

Scale	Herbicidal effect, %	Simptoms of damage	General assessment
1	100	No symptoms - healthy plants	Excellent
2	99,9 – 98	Very mild symptoms - mild suppression	Very good
3	97,9 – 95	Weak but easily recognizable symptoms	Good
4	94,9 – 90	More severe symptoms (eg chlorosis) that do not affect the yield	Satisfactory
5	89,9 – 82	Dilution, severe chlorosis or suppression. Yield reduction is expected	Indefinitely
6	81,9 – 70	Severe damage to death	Unsatisfactory
7	69,9 – 55		Bad
8	54,9 – 30		Very bad
9	29,9 - 0		Absolutely bad

2.2. **Biometric indices** - determined from representative samples of 10 permanently marked plants in four replicates (results are averaged to one plant) as follows:

Plant height (tuff) - is determined by measuring in the center of the tuff from the soil surface to the top of the total mass of inflorescences, in cm.

Tuft diameter - the measurement is made to the row spacing together with the inflorescences, in cm.

Number of inflorescences in one tuft - the inflorescences in one tuft are counted, in no.

Class length - by measuring from the base of the lower flower vertebra to the top of the inflorescence, in cm.

Length of flower stem - the measurement is made from the last pair of leaves to the top of the inflorescence, in cm.

2.3. Yield of fresh inflorescences - is determined by weighing the freshly harvested flower by variants and repetitions recalculated per decare.

2.4. Influence of herbicides on weeding - weeding was performed by the quantitative method, in constant meters in four repetitions, 30 days after the application of herbicides by species (Tonev, T., 2000; Sengalevich T., 1994; Lyubenov J., 1980) .

Technical efficiency

$$K = \frac{N_t}{N_K} * 100$$

N_t – number of weeds in the herbicide-treated plot

N_k – number of weeds in not dug control plot

In the study of the effectiveness of the various herbicides, control without hoeing and treatment was included.

3. Laboratory tests and analyzes

3.1. Extraction of essential oil - The content (as a volume percentage) of essential oil is determined by steam distillation in 5-liter distillation apparatus under direct heating, and the yield is obtained by multiplying the yield of color per unit area and the content of essential oil.

3.2. Chemical composition of the essential oil - according to BDS 3515 (2002) The chemical composition of the essential oil was determined on a gas chromatograph PYE UNICAM series 204, equipped with a flame ionization detector and a capillary column CARBOWAX 20M with hydrogen carrier gas.

Table 2

Chromatographic profile BDS ISO 3515 (2002)

Components	Bulgaria	
	min. %	max. %
Limonene	-	0,6
1,8 cineole	-	2
β - phellandrene	-	0,6
Cis- β- ocimene	3	9
trans-β-ocimene	2	5
3-octanone	0,2	1,6
Camphor	-	0,6
Linalol	22	34
Linalyl acetata	30	42
Lavandulol	0,3	-
Terpinene 4-ol	2	5
Lavandulyl acetate	2	5
α-terpineol	0,8	2

4. Agricultural techniques of experience

The experiment is set in a flowering 5-year plantation of lavender varieties Hemus and Jubilee, created according to the accepted planting scheme - 140 cm. between the rows and 35 cm. in order (Nedkov et al., 2005). Lavender is grown with optimal farming techniques without watering.

The herbicides were applied with a back sprayer at a working solution consumption of 50 l / da. Herbicides are applied to the soil before the lavender vegetation and before the weeds germinate.

The size of the experimental plot is 1.00 x 20 = 20 m2. The species composition of the weeds was reported by the weeding method (Dimitrova et al., 2004), and the degree of weeding by the quantitative method. Harvesting of fresh inflorescences is done manually, by mowing in the flowering phase 75-80% during the warm part of the day.

5. Statistical analysis

To establish statistically significant influences of the studied factors and differences between the tested variants, analysis of variance was applied. Correlation analysis was used to calculate qualitative and quantitative dependencies. Statistical processing of the results was performed by the ANOVA method.

6. **Agrometeorological analyzes**

The data on the meteorological conditions for the time of the study were taken from the agro-meteorological station Kazanlak, located in the Institute of Roses and Essential Oils.

RESULTS AND DISCUSSION

1. Species composition and density of weeds in lavender plantations of Hemus and Jubilee varieties.

The species composition, dynamics and distribution of weed species in the studied weed associations are the result of the complex relationships between the components of the agrophytocenosis and the agroecological conditions of the environment. Depending on the dynamics of the main agrometeorological factors (amount and distribution of precipitation and average daily air temperatures) and the type of cultivated plant during the individual years of study, the dynamics of weed density in the studied agrophytocenoses does not change.

For the specific conditions on average for the period 2011 - 2015, the area on which the study was conducted has a natural background of weeding with a predominant participation of 22 species of weeds, which can be conditionally divided into annual cereals and deciduous and perennial weeds.

Annual weeds

Monocotyledouns
Apera spica venti L.
Setaria viridis L.

Dycotyledouns
Veronica agrestis L.
Sinapis arvensis L.
Stellaria media L.
Fumaria officinalis L.
Polygonum convolvulus L.
Chenopodium album L.
Amaranthus retroflexus L.
Galinsoga parviflora L.
Polygonum aviculare L.
Xantium strumarium L.
Anthemis arvensis L.
Lamium purpureum L.
Capsella bursa-pastoris L.

Perennial weeds
Convolvulus arvensis L.
Cirsium arvense L.
Cardaria draba L.
Sonchus arvensis L.
Cynodon dactylon L.
Artemisia vulgaris L.
Rumex obtusifolius L.

The main group of weeds in the experimental area are annual species, which represent about 60% of the weed association (Tables 3 and 4). The ratio of weeds varies depending on the applied herbicides, soil treatments and their species characteristics. On average for the study period, the weeding in the lavender plantation is of a mixed type with the following quantitative ratio between the individual biological groups:

- Annual monocotyledouns weeds - 10 - 13% in the plantations of both varieties
- Annual dycotyledouns weeds – 54 % in the plantations of both varieties
- Perennial weeds – 33 – 36 % - in the plantations of both varieties

The total density of weeds varies from 70 to 137 pcs / m2 during the years of study in the experimental area of the Hemus variety. The highest density was reported in 2012 and the lowest in 2014. In the experimental area of the Jubilejna variety, the highest number of weeds per 1m^2 was also reported in 2012, and the lowest number in 2015.

Table 3
Species composition of weeds in a plantation of Hemus variety, number / m^2

Species composition of weeds	**Years**					**Average (2011-2015)**
	2011	**2012**	**2013**	**2014**	**2015**	
	number / m^2	number / m^2	number / m^2	number / m^2	number / m^2	number / m^2
I. Annual monocotyledouns weeds						
Apera spica venti L.	0	6	1	6	5	4
Setaria viridis L.	9	7	10	3	2	6
Total	**9**	**13**	**11**	**9**	**7**	**10**
II. Annual dycotyledouns weeds						
Veronica agrestis L.	6	8	6	1	2	5
Stellaria media L.	0	7	1	2	2	2
Fumaria officinalis L.	5	5	6	3	4	5
Sinapis arvensis L.	8	0	0	1	3	2
Polygonum convolvulus L.	4	6	7	0	7	5
Chenopodium album L.	5	10	10	9	4	8
Amaranthus retroflexus L.	8	6	7	10	1	6
Galinsoga parviflora L.	2	10	2	5	3	4
Polygonum aviculare L.	7	1	4	1	5	4
Xantium strumarium L.	3	0	2	4	3	2
Anthemis arvensis L.	4	9	8	2	0	5
Capsella bursa-pastoris L.	6	7	4	3	5	5
Total	**58**	**69**	**57**	**41**	**39**	**53**
III. Perennial weeds						
Convolvulus arvensis L.	8	9	9	7	7	8
Cirsium arvense L.	6	11	4	3	8	6
Cardaria draba L. Desv.	4	10	5	1	4	5
Sonchus arvensis L.	8	6	7	3	3	5
Cynodon dactylon L.	7	8	4	5	5	6
Artemisia vulgaris L.	3	5	4	0	1	3
Rumex obtusifolius L.	0	6	3	1	0	2
Total	**36**	**55**	**36**	**20**	**28**	**35**
Total weeds	**103**	**137**	**104**	**70**	**74**	**98**

Table 4
Species composition of weeds in a plantation of Jubilejna variety, number / m^2

Species composition of weeds	Years					
	2011	2012	2013	2014	2015	Average (2011-2015)
	number / m^2	number / m^2	number / m^2	number / m^2	number / m^2	number / m^2
I. Annual monocotyledouns weeds						
Apera spica venti L.	2	4	5	6	4	4
Setaria viridis L.	8	9	7	3	5	6
Total	**10**	**13**	**12**	**9**	**9**	**11**
II. Annual dycotyledouns weeds						
Veronica agrestis L.	4	5	3	0	5	3
Stellaria media L.	0	6	2	3	0	2
Fumaria officinalis L.	5	8	5	4	3	5
Sinapis arvensis L.	0	6	1	1	3	2
Polygonum convolvulus L.	8	1	0	3	4	3
Chenopodium album L.	7	5	5	6	3	5
Amaranthus retroflexus L.	4	3	8	5	2	4
Galinsoga parviflora L.	7	5	6	5	3	5
Polygonum aviculare L.	6	4	7	4	5	5
Xantium strumarium L.	2	0	1	2	0	1
Anthemis arvensis L.	6	7	5	4	2	5
Lamium purpureum L.	0	2	0	3	5	2
Capsella bursa-pastoris L.	1	5	6	2	3	3
Total	**50**	**57**	**49**	**42**	**38**	**47**
III. Perennial weeds						
Convolvulus arvensis L.	5	3	6	7	5	5
Cirsium arvense L.	3	4	5	3	5	4
Cardaria draba L. Desv.	4	3	2	3	4	3
Sonchus arvensis L.	5	6	4	4	0	4
Cynodon dactylon L.	4	2	6	5	8	5
Artemisia vulgaris L.	3	5	4	0	0	2
Rumex obtusifolius L.	2	5	3	0	2	2
Total	**26**	**28**	**30**	**22**	**24**	**26**
Total weeds	**86**	**98**	**91**	**73**	**71**	**84**

During the studied years there is a dominance of annual deciduous weeds - Chenopodium album L., Fumaria officinalis L., Galinsoga parviflora L., Anthemis arvensis L., Capsella bursa-pastoris L., and of the perennial weeds representatives of the highest density are Convolvulus arvensis L., Cirsium arvense L., Sonchus arvensis L. and Cynodon dactylon L. The percentage by years of the main weed species in the experimental plots is different, but the species diversity is identical (Figures 1 and 2).

Figure 1. Degree of weeding of lavender variety Hemus

Figure 2. Degree of weeding of lavender variety Jubilejna

During the study period, annual cereal weeds accounted for an average of 10% of the weed vegetation in the Hemus plantation and 13% of the Jubilee variety, with a predominant species of Setaria viridis L. Of the annual deciduous species in both plantations, the predominant species are Chenopodium album L., Fumaria officinalis L., Anthemis arvensis L. and Amaranthus retroflexus L., which make up 55% of the total weed vegetation in the experimental areas. Perennial weeds are represented by Convolvulus arvensis L., Cirsium arvense L., Cynodon dactylon L. and Sonchus arvensis L. and occupy 33%.

2. Efficacy of the herbicides tested

2.1 Lavender variety Hemus

In Fig. 3, the dynamics and efficacy of isoxaflutol (calculated as the percentage of weeds destroyed) were monitored. During the years of research isoxaflutole applied in two doses (optimal and increased) has a positive effect on the available weeds. The effect on annual deciduous and cereal weeds reaches 90% after application of the increased dose of isoxaflutol. The efficiency of the optimal herbicide dose is 80%.

Perennial weeds Convolvulus arvensis L., Cirsium arvense L., Cynodon dactylon L. and Sonchus arvensis L. show greater resistance to isoxaflutol. The effectiveness of both doses of the herbicide is from 48 to 53%. With the application of isoxaflutol the test area is kept clean until the 60th day.

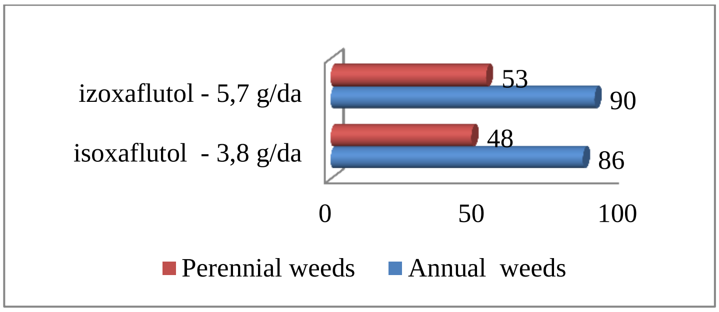


Figure 3. Efficacy of isoxaflutol /% / against available weeds on average for the period 2011-2015

Oxadiargil has shown very good to excellent biological efficacy against annual weeds in the experimental area over the years of study. Applied in high doses, it destroys 93% of them. (Fig. 4). The effectiveness of the herbicide is clearly expressed against Xantium strumarium L., Amaranthus retroflexus L., Chenopodium album L. and Galinsoga parviflora Cav. A lower mortality rate (87%) of annual weeds was reported after the application of the optimal dose of oxadiargyl.

In terms of efficacy against perennial species (56-64%), it is worth noting the effect of oxadiargyl on Convolvulus arvensis L., as one of the main problem weeds in the experimental area. With the application of the increased dose of oxadiargyl, the plots are kept practically clean from the beginning of the lavender vegetation until the fresh inflorescences are harvested.

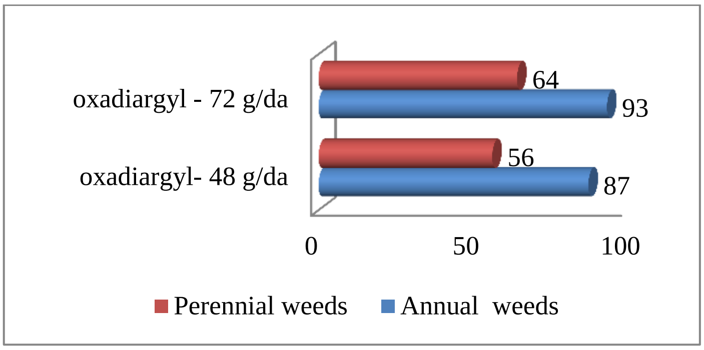


Figure 4. Efficacy of oxadiargyl /% / against available weeds on average for the period 2011-2015

The efficacy of imazamox with respect to annual weeds has remained approximately the same over the years (Fig. 5). When imazamox was applied at a dose of 6 g / da, the effect on annual deciduous and some cereal weeds was 84%. Imported at a higher dose - 9 g / da destroys Apera spica venti L., Setaria viridis L., Chenopodium album L., Galinsoga parviflora Cav., And Xantium strumarium L. with 90% efficiency.

Efficacy results against perennial weeds are similar. The increased dose of the herbicide imazamox more successfully controls perennial weeds such as Cirsium arvense L. and Convolvulus arvensis L.

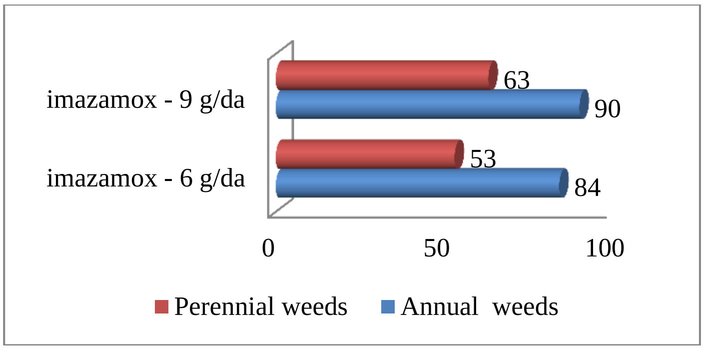


Figure 5. Efficacy of imazamox /% / against available weeds on average for the period 2011-2015

During the years of study, flumioxazine showed very good to excellent biological efficacy against annual weeds in the lavender plantation (Fig. 6). The applied higher dose of the herbicide realizes effective control against the annual and some perennial weeds in the experimental area. The effectiveness of the herbicide is clearly expressed against Amaranthus retroflexus L., Sinapis arvensis L., Chenopodium album L., Polygonum aviculare L., Portulaca oleracea L., Setaria viridis L. and Apera spica venti L. (92%). At the optimal dose, the herbicide kills 88% of annual weeds.

Flumioxazine has a good effect against perennial weeds Convolvulus arvensis L. and Cirsium arvense L., destroying 66% of them when applied in high doses. The duration of the soil herbicidal action of flumioxazine is maintained for about four months.

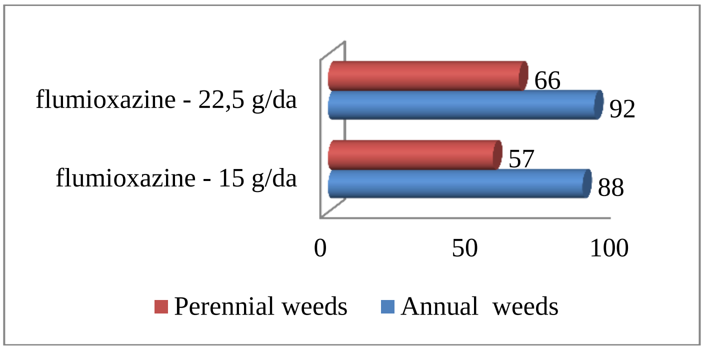


Figure 6. Efficacy of flumioxazine /% / against available weeds on average for the period 2011-2015

2.2 Lavender variety Jubilejna

During the years of research, isoxaflutol applied in both doses had a positive effect on the available weeds. The efficacy against annual deciduous and cereal weeds reached 84-88% after administration of both doses of isoxaflutol (Fig. 7). Perennial weeds show higher resistance to isoxaflutol. The efficacy of the increased herbicide dose is 55%.

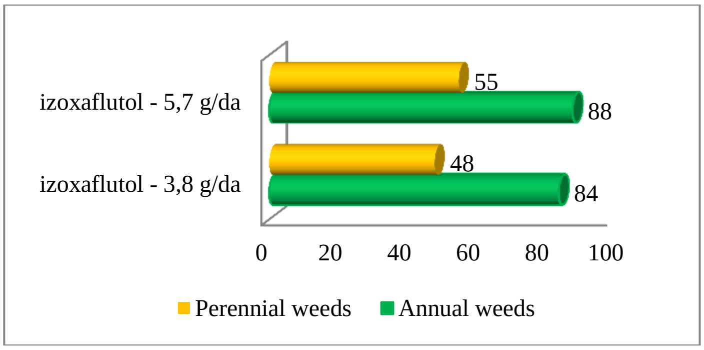


Figure 7. Efficacy of isoxaflutol /% / against available weeds on average for the period 2011-2015

Oxadiargil has shown very good to excellent biological efficacy against annual weeds in the experimental area over the years of study. Applied in the increased dose it destroys up to 92% of them (Fig. 8). The efficacy of the herbicide is clear from Xantium strumarium L., Amaranthus retroflexus L. and Galinsoga parviflora Cav. A lower mortality rate (85%) of annual weeds was reported after the application of the optimal dose of oxadiargyl.

The data from the study of the effectiveness of oxadiargil against weeds in lavender variety Jubilee confirm the results obtained in the variety Hemus.

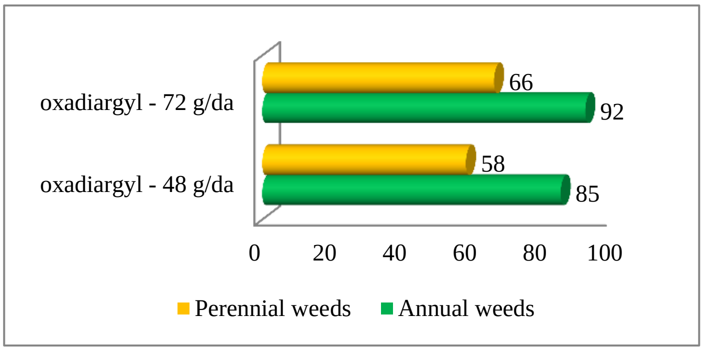


Figure 8. Efficacy of oxadiargyl /% / against available weeds on average for the period 2011-2015

The efficacy of imazamox against annual and perennial weeds is shown in Fig. 9. When imazamox was applied at a dose of 6 g / da, the effect on annual deciduous and some cereal weeds was 90%. Imported at a higher dose - 9 g / da destroys Setaria viridis L., Apera spica venti L., Galinsoga parviflora Cav., Chenopodium album L., Xantium strumarium L. with 90% efficiency.

The increased dose of the herbicide imazamox more successfully controls perennial weeds such as Convolvulus arvensis L. and Cirsium arvense L.

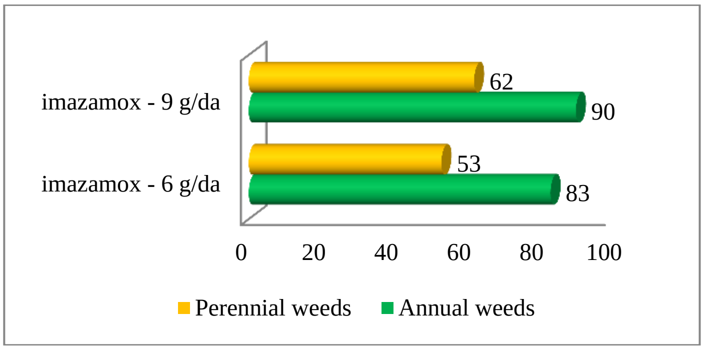


Figure 9. Efficacy of imazamox /% / against available weeds on average for the period 2011-2015

Flumioxazine over the years of study showed very good biological efficacy against annual weeds in the experimental area (Fig. 10). The higher dose of the herbicide applied provides effective control against annual and some perennial weeds. The effectiveness of the herbicide is clearly expressed against Amaranthus retroflexus L., Sinapis arvensis L., Chenopodium album L., Polygonum aviculare L., Portulaca oleracea, Setaria viridis and Apera spica venti L. (92%). At the optimal dose, the herbicide kills up to 87% of annual weeds.

Flumioxazine has a good effect against perennial weeds Convolvulus arvensis L. and Cirsium arvense L., destroying 71% of them in 2012 and 2015, applied in the increased dose.

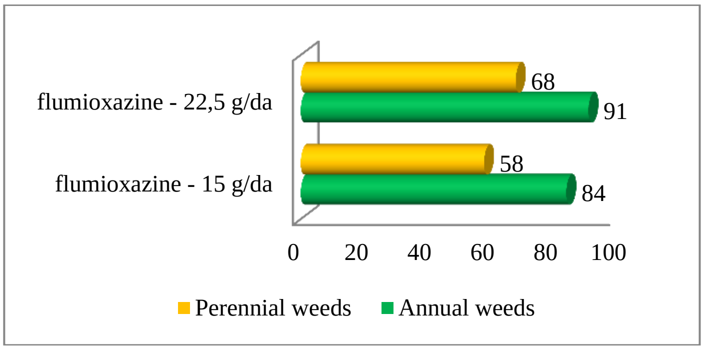


Figure 10. Efficacy of flumioxazine /% / against available weeds on average for the period 2011-2015

3. Selectivity of the tested herbicides

The tolerance of each plant species to a particular herbicide is within certain limits. When the dose exceeds the recommended limits and when the herbicide treatment is carried out in adverse weather conditions, phytotoxicity may occur. It is expressed in visual manifestations such as chlorosis, necrosis, growth retardation and retardation, etc. The results of visual readings in phytotoxicity scores on the EWRS scale (Table 5) show that isoxaflutol at a dose of 3.8 g / da, oxadiargyl, imazamox and flumioxazine administered at these doses show excellent selectivity for lavender varieties Hemus and Yubi. No phytotoxic changes in plants were observed throughout the study period. Isoxaflutol at a dose of 5.7 g / da shows low phytotoxicity (score 2-3), which is expressed in mild to moderate chlorosis of plants of both varieties of lavender, and after the 20th day is overcome.

Table 5. Selectivity of the tested herbicides to the two varieties of lavender (Jubilejna and Hemus) on average for the period 2011 - 2015

Active substance of the preparation	Herbicide preparation	Dose, g/da	Ball of damage (EWRS) Days after treatment		
			7	20	30
750 g/kg izoxaflutol	Merlin 750 VG	3,8	1	1	1
		5,7	3	2	1
400 g/l oxadiargyl	Raft 400 SK	48	1	1	1
		72	1	1	1
40 g/l imazamox	Pulsar 40	6	1	1	1
		9	1	1	1
500 g/kg flumioxazine	Pledge 50 VP	15	1	1	1
		22,5	1	1	1

4. Economic productivity of lavender plantations depending on the variety, growing conditions and applied herbicides

The main criterion determining the economic qualities of a lavender variety is its productivity (high yield of fresh inflorescences, high yield and high quality of essential oil). The timely application of soil herbicides is one of the main factors contributing to the regulation of yield. Determining the most appropriate doses of imported herbicides depending on the variety and the specific climatic conditions are a key element of lavender farming techniques.

4.1. Yield of fresh lavender flowers.

The results of the five-year experiment on the effect of isoxaflutol at a dose of 3.8 g / da (optimal dose) are one-way and show that the preparation increases the yield of Hemus variety by 67 kg / da and Jubilee variety by 65 kg / da, which is statistically proven (Tables 6 and 7).

Table 6. Yield of fresh lavender flowers of Hemus variety after treatment with isoxaflutole, on average for the period 2011-2015

Variant	Average yield kg/da ($\overline{x}$)	differences (+/-D)	% K
Untreated control	401		100
izoxaflutol - 3,8 g/da	**468 *** **	**67**	**117**
izoxaflutol - 5,7 g/da	**495 *** **	**94**	**123**
GD 5%	**11**		
1%	**15**		
0,1%	**21**		

Table 7. Yield of fresh lavender flowers of Jubilejna variety after treatment with isoxaflutole, on average for the period 2011-2015

Variant	Average yield kg/da ($\overline{x}$)	differences (+/-D)	% K
Untreated control	433	-	100
izoxaflutol - 3,8 g/da	**498 *** **	**65**	**115**
izoxaflutol - 5,7 g/da	**559 *** **	**126**	**129**
GD 5%	**28**		
1%	**39**		
0,1%	**56**		

The test of oxadiargyl at doses of 48 and 72 g / da significantly increased the amount of color. The highest yield was harvested at the Jubilee variety - 594 kg / da and the Hemus variety - 570 kg / da at 72 g / da oxadiargyl. Applied at a dose of 48 g / da, the herbicide increases the yield of fresh flowers by 111 kg / da (125% of K) for the Jubilejna variety and by 63 kg / da (126% of K) for the Hemus variety. The results are statistically proven at a level of significance of differences of 0.1% in the two varieties of lavender (Tables 8 and 9).

Table 8. Yield of fresh lavender flowers of Hemus variety after treatment with oxadiargyl, on average for the period 2011-2015

Variant	Average yield kg/da ($\overline{x}$)	differences (+/-D)	% K
Untreated control	401		100
oxadiargyl - 48 g/da	**507 *** **	**106**	**126**
oxadiargyl - 72 g/da	**570 *** **	**169**	**142**
GD 5%	**33**		
1%	**46**		
0,1%	**66**		

Table 9. Yield of fresh lavender flowers of Jubilejna variety after treatment with oxadiargyl, on average for the period 2011-2015

Variant	Average yield kg/da ($\bar{x}$)	differences (+/-D)	% K
Untreated control	433	-	100
oxadiargyl - 48 g/da	**544 *****	**111**	**125**
oxadiargyl - 72 g/da	**594 *****	**161**	**137**
GD 5%	**13**		
1%	**18**		
0,1%	**26**		

On average for the period, the yields of lavender flowers at the low tested dose of imazamox are: for the variety Jubilee - 524 kg / da, for the variety Hemus - 506 kg / da. With the application of the increased dose (9 g / da) there is an increase in yields: for the variety Jubilejna - 581 kg / da, for the variety Hemus - 559 kg / da (Tables 10 and 11). The results are statistically proven.

Table 10. Yield of fresh lavender flowers of Hemus variety after treatment with imazamox, on average for the period 2011-2015

Variant	Average yield kg/da ($\bar{x}$)	differences (+/-D)	% K
Untreated control	401	-	100
imazamox - 6 g/da	**506 *****	**105**	**126**
imazamox - 9 g/da	**559 *****	**158**	**139**
GD 5%	**17**		
1%	**25**		
0,1%	**35**		

Table 11. Yield of fresh lavender flowers of Jubilejna variety after treatment with imazamox, on average for the period 2011-2015

Variant	Average yield kg/da ($\bar{x}$)	differences (+/-D)	% K
Untreated control	433	-	100
imazamox - 6 g/da	**524 *****	**91**	**121**
imazamox - 9 g/da	**581 *****	**148**	**134**
GD 5%	**24**		
1%	**34**		
0,1%	**48**		

Regarding the effect of flumioxazine, studied at a dose of 15 g / da, the preparation increases the yield of fresh flowers in the highest degree in the variety Jubilee to 519 kg / da followed by the variety Hemus - 512 kg / da (Tables 12 and 13). The results are statistically proven at GD 0.1%.

Table 12. Yield of fresh lavender flowers of Hemus variety after treatment with flumioxazine, on average for the period 2011-2015

Variant	Average yield kg/da ($\overline{x}$)	differences (+/-D)	% K
Untreated control	401	0	0
flumioxazine - 15 g/da	**512 *** **	**111**	**128**
flumioxazine – 22,5 g/da	**571 *** **	**170**	**142**
GD 5%	**17**		
1%	**24**		
0,1%	**35**		

Table 13. Yield of fresh lavender flowers of Jubilejna variety after treatment with flumioxazine, on average for the period 2011-2015

Variant	Average yield kg/da ($\overline{x}$)	differences (+/-D)	% K
Untreated control	433	-	100
flumioxazine - 15 g/da	**519 *** **	**86**	**120**
flumioxazine – 22,5 g/da	**589 *** **	**156**	**136**
GD 5%	**33**		
1%	**46**		
0,1%	**66**		

4.2. Yield of essential oil

The formation of the yield and quality of lavender essential oil, among other factors, is closely dependent on the effect of herbicides applied. Therefore, one of the main indicators in determining the effectiveness of the application of herbicides to control weeds in lavender is to determine their impact on the quantity and quality of essential oil.

The results of the five-year experiment on the effect of isoxaflutol at a dose of 3.8 g / da (optimal dose) are one-way and show that the preparation increases the yield of essential oil in the variety Jubilejna by 1 kg / da and the variety Hemus by 0.9 kg / da , which is statistically proven (Tables 14 and 15).

Table 14. Yield of lavender essential oil of the Hemus variety after treatment with isoxaflutol, on average for the period 2011-2015

Variant	Average yield kg/da ($\overline{x}$)	differences (+/-D)	% K
Untreated control	6,3	-	100
izoxaflutol - 3,8 g/da	**7,2 *** **	**0,9**	**114**
izoxaflutol - 5,7 g/da	**8,1 *** **	**1,8**	**129**
GD 5%	**0,3**		
1%	**0,4**		
0,1%	**0,6**		

Table 15. Yield of lavender essential oil of the Jubilejna variety after treatment with isoxaflutol, on average for the period 2011-2015

Variant	Average yield kg/da (x̅)	differences (+/-D)	% K
Untreated control	7,8	-	100
izoxaflutol - 3,8 g/da	**8,8 ****	**1**	**112**
izoxaflutol - 5,7 g/da	**9,1 *****	**1,3**	**116**
GD 5%	**0,5**		
1%	**0,7**		
0,1%	**1,1**		

Under the experimental conditions, isoxaflutol at a dose of 5.7 g / da leads to an increase in yield by 1.8 kg / da in the Hemus variety and by 1.3 kg / da in the Jubilejna variety. These results are statistically proven.

Testing oxadiargil at doses of 48 and 72 g / da significantly increased oil yield. The highest yield was harvested in the Jubilee variety - 11.2 kg / da and the Hemus variety - 9.4 kg / da at 72 g / da oxadiargyl. Applied at a dose of 48 g / da, the herbicide increased the yield by 2.2 kg / da (135% of K) for the Hemus variety and by 2.1 kg / da (126% of K) for the Jubilejna variety. The results are statistically proven at a level of significance of differences of 0.1% for the two varieties of lavender (Tables 16 and 17).

Table 16. Yield of lavender essential oil of the Hemus variety after treatment with oxadiargyl, on average for the period 2011-2015

Variants	Average yield kg/da (x̅)	differences (+/-D)	% K
Untreated control	6,3	-	100
oxadiargyl - 48 g/da	**8,5 *****	**2,2**	**135**
oxadiargyl - 72 g/da	**9,4 *****	**3,1**	**149**
GD 5%	**0,3**		
1%	**0,4**		
0,1%	**0,6**		

Table 17. Yield of lavender essential oil of the Jubilejna variety after treatment with oxadiargyl, on average for the period 2011-2015

Variants	Average yield kg/da (x̅)	differences (+/-D)	% K
Untreated control	7,8	-	100
oxadiargyl - 48 g/da	**9,9 *****	**2,1**	**126**
oxadiargyl - 72 g/da	**11,2 *****	**3,4**	**143**
GD 5%	**0,4**		
1%	**0,5**		
0,1%	**0,8**		

On average for the period, the yields of lavender oil at the low tested dose of imazamox are: for the variety Jubilejna - 9.4 kg / da, for the variety Hemus - 7.8 kg / da. With the application of the increased dose (9 g / da) there is an increase in yields: for the variety Jubilejna - 10.9 kg / da, for the variety Hemus - 8.9 kg / da (Tab. 18 and 19). The results are statistically proven at a level of significance of differences of 0.1%.

Table 18. Yield of lavender essential oil of the Hemus variety after treatment with imazamox, on average for the period 2011-2015

Variants	Average yield kg/da ($\overline{x}$)	differences (+/-D)	% K
Untreated control	6,3	-	100
imazamox - 6 g/da	**7,8 *****	**1,5**	**124**
imazamox - 9 g/da	**8,9 *****	**2,6**	**141**
GD 5%	**0,5**		
1%	**0,6**		
0,1%	**1**		

Table 19. Yield of lavender essential oil of the Jubilejna variety after treatment with imazamox, on average for the period 2011-2015

Variants	Average yield kg/da ($\overline{x}$)	differences (+/-D)	% K
Untreated control	7,8	-	100
imazamox - 6 g/da	**9,4 *****	**1,6**	**120**
imazamox - 9 g/da	**10,9 *****	**3,1**	**140**
GD 5%	**0,5**		
1%	**0,7**		
0,1%	**1**		

Regarding the effect of flumioxazine, studied at a dose of 15 g / da, the preparation increases the yield of essential oil in the highest degree in the variety Jubilejna to 9.7 kg / da followed by the variety Hemus 8.1 kg / da (Table 20 and 21). The results are statistically proven at GD 0.1%.

Studies from five years of experience on the effect of flumioxazine at a dose of 22.5 g / da show that the preparation increases the yield in the variety Jubilejna by 3.4 kg / da, in the variety Hemus by 2.6 kg / da. It should be noted that these results are statistically proven at P 0.1%.

Table 20. Yield of lavender essential oil of the Hemus variety after treatment with flumioxazine, on average for the period 2011-2015

Variants	Average yield kg/da ($\overline{x}$)	differences (+/-D)	% K
Untreated control	6,3	-	100
flumioxazine - 15 g/da	**8,1 *****	**1,8**	**128**
flumioxazine – 22,5 g/da	**8,9 *****	**2,6**	**141**
GD 5%	**0,2**		
1%	**0,3**		
0,1%	**0,5**		

Table 21. Yield of lavender essential oil of the Jubilejna variety after treatment with flumioxazine, on average for the period 2011-2015

Variants	Average yield kg/da (x̄)	differences (+/-D)	% K
Untreated control	7,8	-	100
flumioxazine - 15 g/da	**9,7 *****	**1,9**	**124**
flumioxazine – 22,5 g/da	**11,2 *****	**3,4**	**143**
GD 5%	**0,3**		
1%	**0,4**		
0,1%	**0,6**		

An important indicator determining the yield of essential oil is the content of essential oil. The individual varieties, branches or origins sometimes differ significantly in this respect (Boyadzhieva, 1975). In addition, climatic conditions during growth and development, especially during flowering and harvesting of lavender, the application of herbicides and others. can have a significant effect on the content of essential oil.

The data from the study show that the herbicides in the individual years of study did not adversely affect the content of essential oil in the fresh lavender color of the individual variants. In the case of the Jubilee variety, an increase of this indicator by 0.5% was observed at the high doses of oxadiargyl, imazamox and flumioxazine compared to the control for 2014 and 2015 (Figs. 11 and 12).

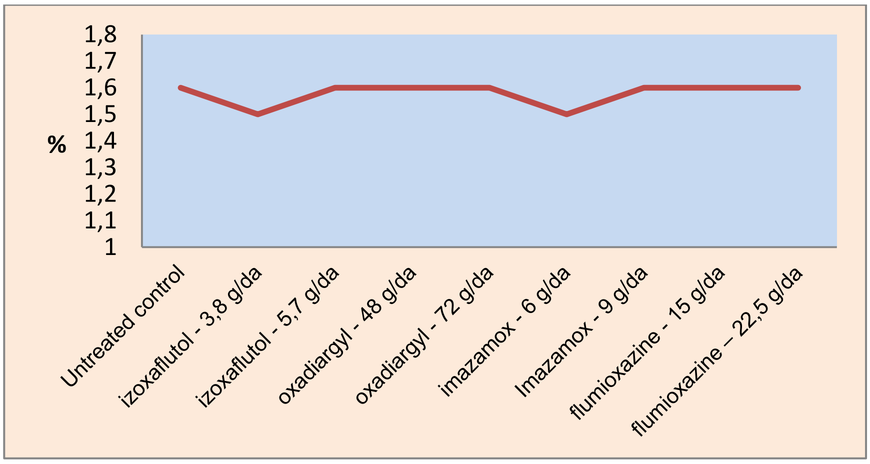


Figure 11. Essential oil content in the color of a variety Hemus average for the period 2011-2015 year

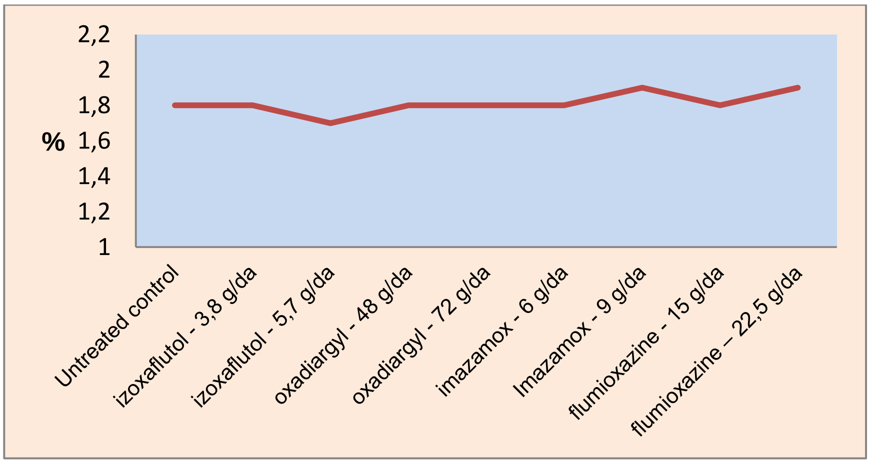


Figure 12. Essential oil content in the color of a variety Jubilejna average for the period 2011-2015 year

4.3. Biometric indicators

The biometric approach in the study of natural phenomena is necessary primarily due to the variability of organisms under the influence of genetic causes and environmental conditions, which leads to their diversity or variation (Genchev, 1975).

To a large extent, the values of some morphological features of lavender such as plant height, width, number of inflorescences and their variation are directly related to important economic indicators, such as inflorescence yield, essential oil content and yield, suitability for mechanized harvesting and so called

The height of the Hemus variety (Table 22) in the treated variants was 2.7 to 8 cm higher than in the control (K). Isoxaflutol and imazamox at a dose of 6 g / da in the significance of the differences are from the untreated control group. In the other variants, the differences were statistically proven at a significance level of GD 5 and 1%.

The data in the table show that the height of the plants is the highest in the variants with the application of the increased dose of oxadiargyl, imazamox and flumioxazine. In the reduced dose variants, a slight decrease of 0.7 to 2.9 cm was observed.

Regarding the diameter of the tuft with the largest size (75.5 cm), the variant with oxadiargyl at a dose of 72 g / da is distinguished, followed by flumioxazine at a dose of 22.5 g/da (72.8 cm). The diameter of the plants in the control variant is 65.3 cm. All other variants outperform the control on this indicator by 3.9 to 7.5 cm. The results are statistically proven at a significance level of P 1 and 0.1%.

The only exception is isoxaflutol at a dose of 3.8 g / da with an unproven difference. The number of inflorescences is a very important factor that largely determines the content and yield of essential oil. The number of inflorescences in the untreated control of Hemus variety is 282. According to this indicator, the variation of the herbicide-treated variants is from 311 to 350. The differences with the control variant are from 29 to 68 inflorescences. They are statistically proven at GD 1 and 0.1%.

The class length averaged 5.8 cm over the control period. It is noteworthy that the class length of oxadiargyl, imazamox and flumioxazine administered at the low dose was 6.4 cm. As the dose is increased, the height reaches 6.6-6.7 cm. Differences with the control variant were statistically demonstrated at a significance level of P 5% for isoxaflutol at a dose of 3.8 g / da and P 0.1% for all other variants.

It is known that the length of the flower stalk often depends on the possibility of mechanized harvesting of a variety. On the other hand, excessively long and thick flowering stems are a significant part of the weight of the inflorescence, significantly increasing the yield of the obtained essential oil.

The length of the flower stalk does not change significantly in the individual variants of the experiment. The differences in this indicator between the herbicides and the control vary from 0.6 to 3.2 cm. They were statistically proven for isoxaflutol at a dose of 5.7 g / da at GD 5% and oxadiargyl, imazamox and flumioxazine at increased doses at GD 1%.

Table 22. Biometric indicators for Hemus variety, average for the period 2011-2015

Variants	Plant height, cm	Plant diameter, cm	Number of inflorescences	Class length, cm	Length of flower stem, cm
Untreated control	52,0	65,3	282	5,8	21,7
izoxaflutol - 3,8 g/da	$54,7^{n.s.}$	$69,2^{n.s.}$	311^{**}	$6,2^{*}$	$22,3^{n.s.}$
izoxaflutol - 5,7 g/da	$56,5^{n.s.}$	$71,2^{**}$	320^{***}	$6,4^{***}$	$24,0^{*}$
oxadiargyl - 48 g/da	$57,1^{*}$	$72,3^{**}$	330^{***}	$6,4^{***}$	$23,6^{n.s.}$
oxadiargyl - 72 g/da	$60,0^{**}$	$75,5^{***}$	349^{***}	$6,7^{***}$	$24,9^{**}$
imazamox - 6 g/da	$56,0^{n.s.}$	$71,2^{**}$	321^{***}	$6,4^{***}$	$23,5^{n.s.}$
imazamox - 9 g/da	$57,1^{*}$	$72,3^{**}$	331^{***}	$6,6^{***}$	$24,7^{**}$
flumioxazine - 15 g/da	$58,4^{*}$	$72,0^{**}$	326^{***}	$6,4^{***}$	$23,5^{n.s.}$
flumioxazine – 22,5 g/da	$59,1^{**}$	$72,8^{**}$	350^{***}	$6,7^{***}$	$24,9^{**}$

The height of the Jubilejna variety in the tested variants is 3.8 to 8 cm higher than that in the control (K). In all tested variants, the differences were statistically proven at a significance level of GD 5; 1; 0.1% (Table 23).

The data in the table show that the height of the plants is the highest in the variants with the application of the increased dose of oxadiargyl, imazamox and flumioxazine as in the Hemus variety. In the reduced dose variants, a slight decrease of 2 to 2.2 cm is also reported here.

The results confirm the positive effect of herbicides on this indicator.

Regarding the diameter of the tuft with the largest size (83.8 cm), the variant with flumioxazine at a dose of 22.5 g / da is distinguished. The diameter of the plants in the control variant is 75 cm. All other variants exceed the control on this indicator by 1.7 to 7.5 cm. The results are statistically proven at a significance level of P 5; 1; 0.1%. The only exception is isoxaflutol at a dose of 3.8 g / da with an unproven difference.

The number of inflorescences in the untreated control of the Jubilejna variety is 326. According to this indicator, the variation of the herbicide-treated variants is from 333 to 404. The differences with the control variant are from 7 to 78 inflorescences. They are statistically proven in GD 5; 1; 0.1%. The differences between the control and isoxaflutol (3.8 and 5.7 g / da) were not statistically proven.

The class length averaged 6.8 cm over the control period. In oxadiargyl, imazamox and flumioxazine administered in the low dose it is 7.1-7.3 cm. With increasing dose it reaches 7.5-7.7 cm. The differences with the control variant were proved statistically at a significance level of P 5; 1; 0.1% in all variants, except for isoxaflutol at a dose of 3.8 g / da and imazamox - 6 g / da.

It is established from Table 57 that the length of the flower stalk does not change significantly in the individual variants of the Jubilee variety. The difference in this indicator between the herbicides and the control is from 0.6 to 3.3 cm. They were statistically proven for isoxaflutol at a dose of 5.7 g / da at GD 5% and oxadiargyl, imazamox and flumioxazine at increased doses at GD 5; 1%.

Table 23. Biometric indicators for Jubilejna variety, average for the period 2011-2015

Variants	Plant height, cm	Plant diameter, cm	Number of inflorescences,	Class length, cm	Length of flower stem, cm
Untreated control	55,3	75,0	326,0	6,8	23,3
izoxaflutol - 3,8 g/da	$59,1^{*}$	$76,7^{n.s.}$	$333,0^{n.s.}$	$6,9^{n.s.}$	$23,9^{n.s.}$
izoxaflutol - 5,7 g/da	$61,3^{**}$	$80,8^{**}$	$347,0^{n.s.}$	$7,2^{*}$	$25,1^{*}$
oxadiargyl - 48 g/da	$60,2^{**}$	$79,0^{*}$	$364,0^{**}$	$7,2^{*}$	$24,6^{n.s.}$
oxadiargyl - 72 g/da	$62,2^{***}$	$82,5^{***}$	$404,0^{***}$	$7,6^{***}$	$26,3^{**}$
imazamox - 6 g/da	$59,3^{*}$	$80,0^{**}$	$361,0^{*}$	$7,1^{n.s.}$	$24,5^{n.s.}$
imazamox - 9 g/da	$62,3^{***}$	$83,7^{***}$	$371,0^{**}$	$7,5^{***}$	$26,0^{**}$
flumioxazine - 15 g/da	$61,2^{**}$	$81,8^{***}$	$362,0^{*}$	$7,3^{*}$	$24,2^{n.s.}$
flumioxazine – 22,5 g/da	$63,3^{***}$	$83,8^{***}$	$386,0^{***}$	$7,7^{***}$	$25,3^{*}$

4. Chemical composition of the essential oil

The quality of lavender oil depends on a number of factors, the most important of which are: varietal composition, environmental conditions, agricultural techniques, technology of harvesting and processing of flowers and others.

1.8 cineole, cis-β-ocimene, trans-β-ocimene, linalool, camphor, lavender, terpinene-4-ol, linalilacetate and lavendyl acetate (ISO 3515: 2002) are defined as the main quality chemical constituents of lavender oil.

Ocemic and cineole are mentioned in the literature as determining the odor for lavender oil. From the results obtained for the content of 1,8-cineole in the variety Hemus it is observed that during the study period the variants with herbicides and control correspond to the values of BDS. The control variant, imazamox at a dose of 6 g / da and flumioxazine (15g /da) in 2014 have values close to the upper limit.

For the Jubilejna variety, the content of 1,8-cineole for all studied years is less than 1% in the variants with herbicides and untreated control (Figs. 13 and 14).

Cis-β-ocimene often has values that are much lower than the lower limit of the standard. This is observed for the Hemus variety for all variants and controls included in the experiment, which have values below 3%. These results are maintained during the five years of study.

Variants of the Jubilejna variety have a content of this chemical ingredient within the limits of the standard in the individual years. A lower percentage of cis-β-ocimene (1.1%) in the control was observed in 2013.

The trans-β-ocimene has the same patterns observed in the study of cis-β-ocimene. Here again, isoxaflutole, oxadiargyl, imazamox, flumioxazine in the tested doses and the untreated control of the Hemus variety have values lower than the lower limits of the standard.

The herbicide variants for the Jubilejna variety have values within the standard. The controls, isoxaflutole and flumioxazine in 2012 and 2013 had values below 2%.

The main ingredients in lavender oil are linalilacetate - 30-50% and linalool - 26-46% (Balinova-Tsvetkova, 2014).

The linalool content of the Hemus herbicide variants in the first year of the study ranged from 31.1 to 35.3%. In the control variant, the value of linalool is 28.1%. In 2012 and 2015, an increase in linalool values was observed in all variants of the experiment. They are the highest in the control and reach 42.4 and 45%, which significantly exceeds the standard. For the remaining two years of the study, the linolol values were close to the permissible upper limit.

The content of linalool in the essential oil of the Jubilejna variety in isoxaflutol, oxadiargyl, imazamox and flumioxazine for the study period is 22 to 32.8%, which fully meets the Bulgarian standard.

Camphor is known to be an unwanted ingredient in lavender oil. Its values in all herbicide-treated variants and the control of the Hemus and Jubilee varieties meet the standard. The content of camphor in essential oils does not exceed 0.5%. This is one of the reasons why our lavender varieties are of high quality.

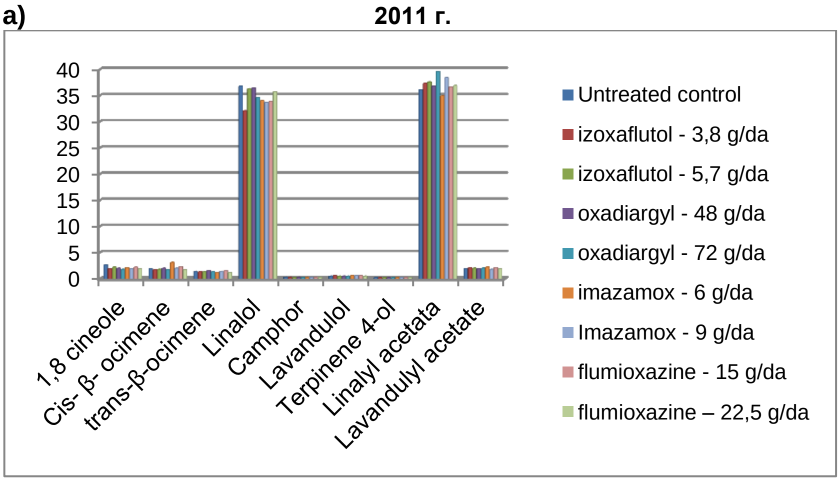
When comparing the content of lavender in the variants with herbicides and the control in the varieties of lavender, the same regularities were found, which we noted in the study of camphor. The values in the individual years are very close. The requirement of the standard is content over 0.3%. Herbicide-treated variants and controls meet this condition for both varieties.

The amount of terpinene-4-ol in the essential oil from the herbicide samples and the Hemus variety control is characterized by a low content of up to 0.6%. This is observed for the entire study period.

With regard to terpinene-4-ol in the variants of the Jubilejna variety, a high content (over 6%) was observed throughout the study period.

Figure 13. Chemical composition of the essential oil of the Hemus variety

a)



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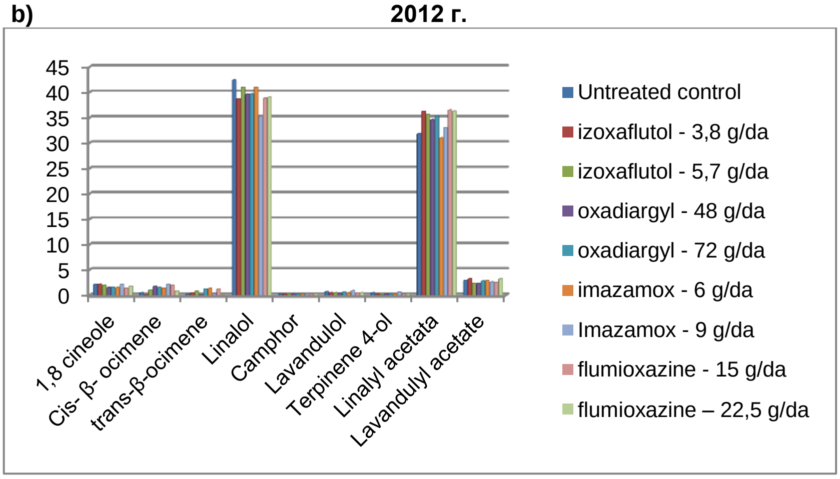
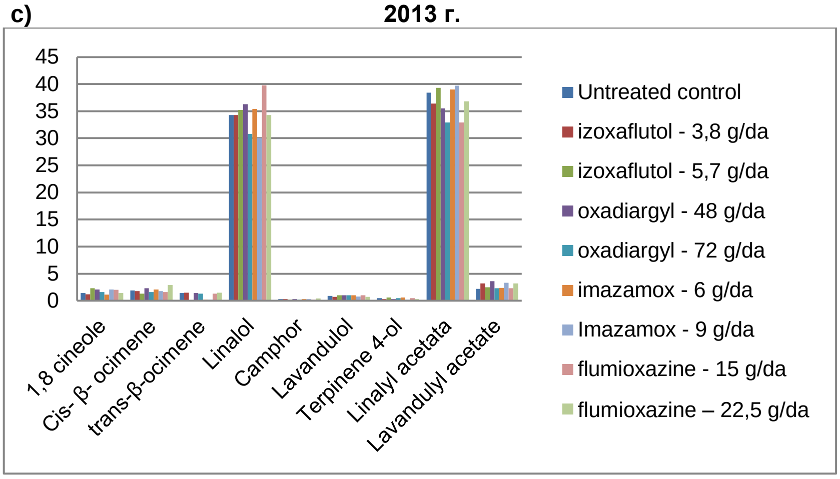
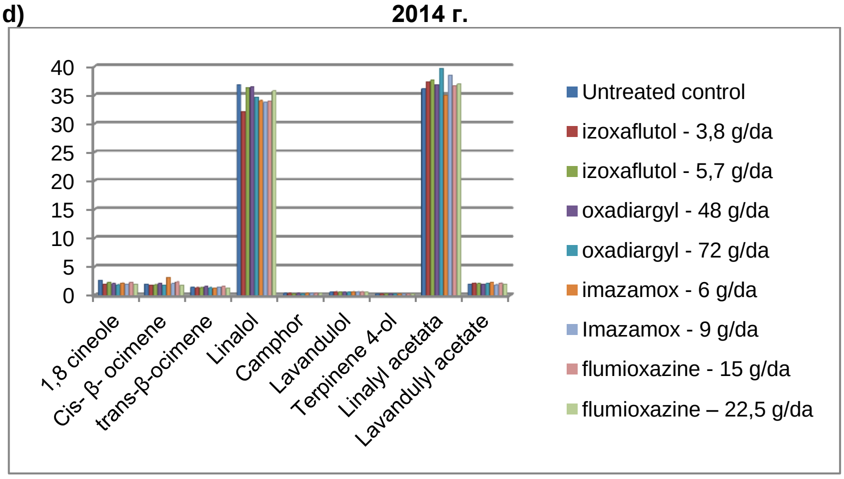


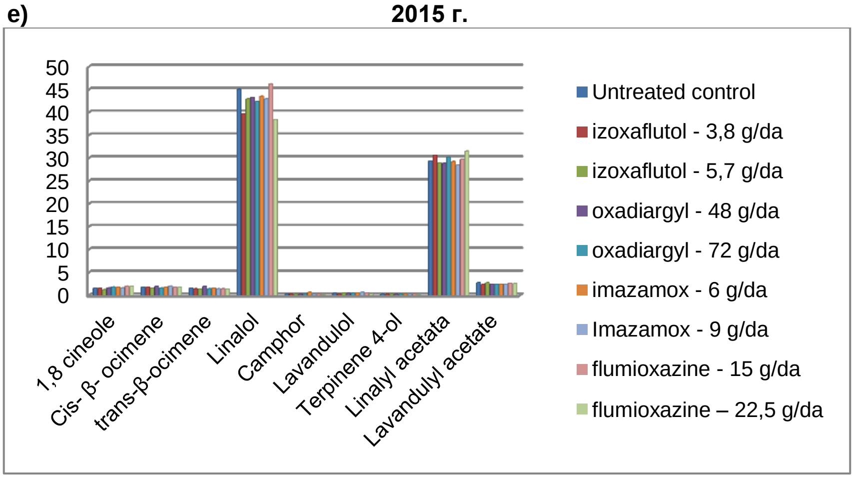
c) 2013 г.



d) 2014 г.



e) 2015 г.



Linalyl acetate is the other main ingredient in lavender oil. According to the Bulgarian standard, its content should be between 30 and 42%. The variants with herbicides and the control for the variety Hemus for the period from 2011 to 2015 are within the limits of the standard or are close to its values.

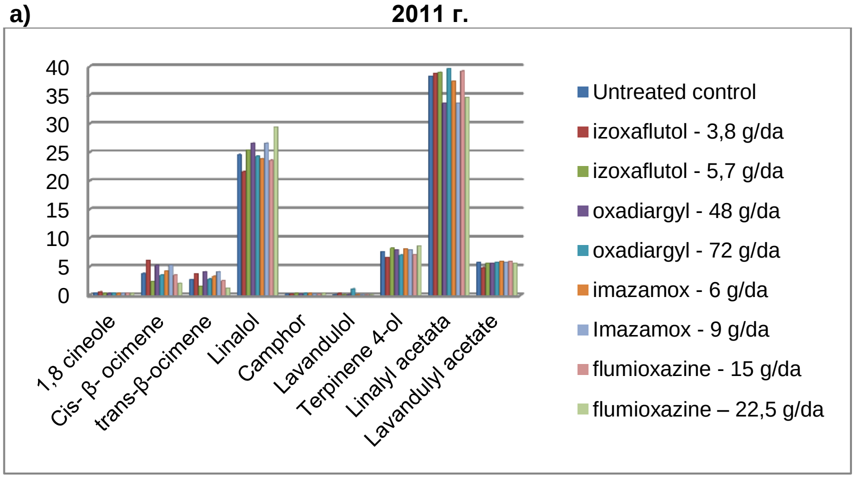
The values of linalilacetate for isoxaflutol, oxadiargyl, imazamox and flumioxazine for the Jubilejna variety meet the quality standard of lavender oil with values from 30 to 39.6% for the period from 2011 to 2015.

Another important ingredient in the quality of lavender oil is lavender acetate. If we compare the content of this ingredient in the essential oils of the herbicide variants and the untreated control of the Hemus variety, we will notice that all variants have very similar values (2.6-3.2%). Lavender acetate values were stable for the herbicides tested throughout the study period.

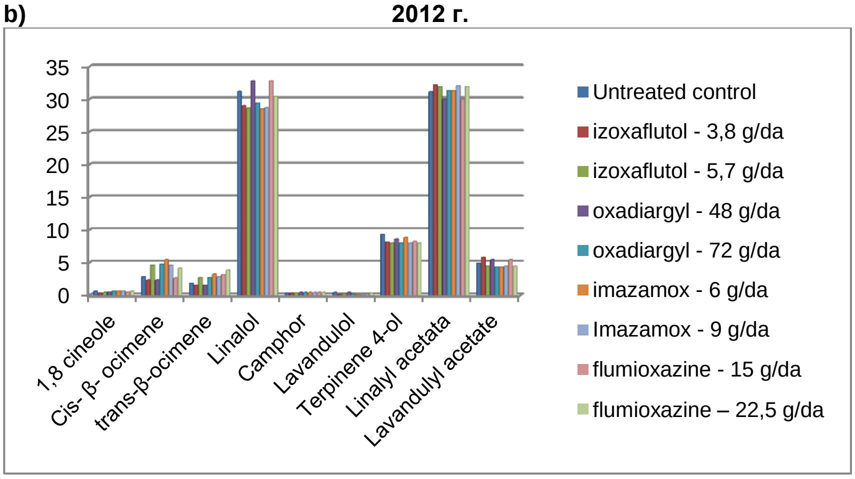
With regard to lavender acetate in the Jubilejna variety, a higher content of over 5.5% was observed for all variants in 2011. During the period 2012-2015, lavender acetate in the herbicide variants had values corresponding to the standard or close to the upper limit.

Figure 14. Chemical composition of the essential oil of the Jubilejna variety

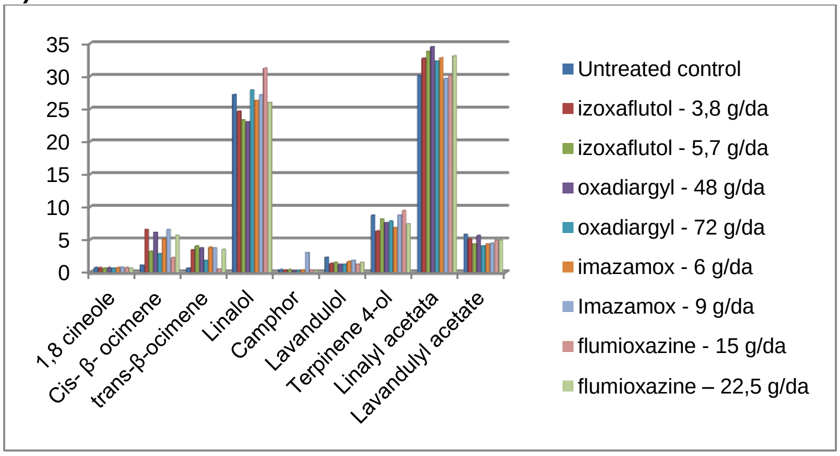
a) **2011 г.**



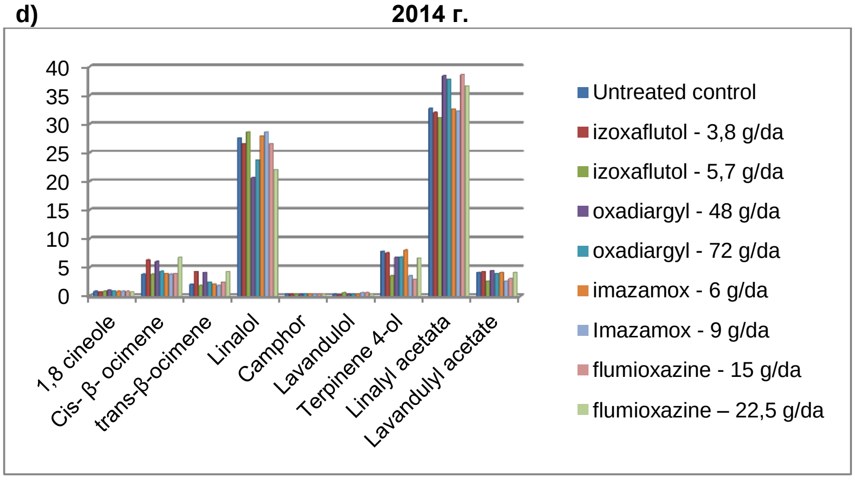
b) **2012 г.**



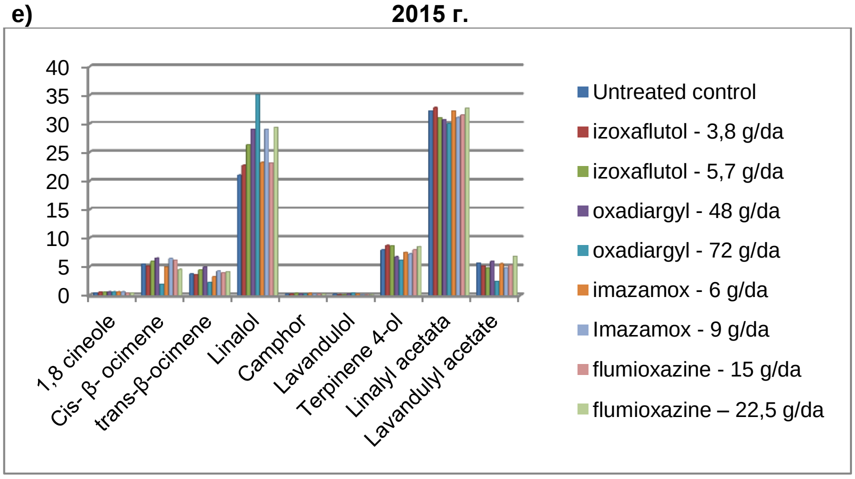
c) **2013 г.**



d) **2014 г.**



e) **2015 г.**



In conclusion, it should be noted that the quantitative differences for some chemical components can be considered as a varietal trait and not as a result of the application of soil herbicides.

CONCLUSIONS

1. The experimental areas are dominated by species from the group of annual cereal and deciduous weeds - Setaria viridis L., Chenopodium album L., Amaranthus retroflexus L., Anthemis arvensis L., Capsella bursa-pastoris L. and Polygonum aviculare L., and from perennial species are Convolvulus arvensis L., Cirsium arvense L., Cynodon dactylon L. and Sonchus arvensis L.

2. The highest efficacy in both varieties of lavender was observed with oxadiargyl administered at a dose of 72 g/da (95%). The action of the herbicide is clearly expressed against Xantium strumarium L., Amaranthus retroflexus L., Chenopodium album L. and Galinsoga parviflora Cav. It has a very good herbicidal effect on Convolvulus arvensis L.

3. Flumioxazine, applied at a dose of 22.5 g/da, carries out effective control against annual weeds Amaranthus retroflexus L., Sinapis arvensis L., Chenopodium album L., Polygonum aviculare L., Portulaca oleracea (92%). The herbicide has a good effect against perennial weed species Convolvulus arvensis L. and Cirsium arvense L. (71%).

4. The efficacy of imazamox against annual weeds over the years is maintained above 89% at a dose of 9 g/da. The herbicide destroys Apera spica venti L., Setaria viridis L., Chenopodium album L., Galinsoga parviflora Cav. and Xantium strumarium L.

5. The effect on annual weeds reaches 90-92% after the application of the increased dose of isoxaflutol. Perennial weeds Convolvulus arvensis L., Cirsium arvense L., Cynodon dactylon L. and Sonchus arvensis L. show higher resistance to the herbicide.

6. The varieties Hemus and Jubilejna show good tolerance to the herbicides oxadiargil, imazamox and flumioxazine.

7. When treated with isoxaflutol at a dose of 5.7 g/da on lavender plants of both varieties, low phytotoxicity is observed, which is expressed in weak chlorosis, which is overcome by the 30th day.

8. Higher productivity of lavender is observed when using herbicides in high doses. On average for the period, the highest yield of Jubilejna flower was obtained with oxadiargyl - 623 kg/da, from Hemus with flumioxazine - 571 kg/da.

9. In terms of the amount of essential oil obtained, on average during the study period the highest yield was harvested in the Jubilejna variety - 11.2 kg /da after treatment with oxadiargyl at a dose of 72 g da and flumioxazine 22.5g/da.

10. The highest yield of Hemus essential oil was obtained after the application of oxadiargyl (72 g/da) - 9.4 kg/da and flumioxazine (22.5 g/da) - 8.9 kg/da.

11. The amount of Jubilejna lavender oil obtained after administration of 5.7 g/da isoxaflutol exceeds by only 4% the amount of the optimal dose (3.8 g/da).

12. The studied herbicides do not have a negative effect on the biometric parameters of lavender plants of both varieties. Statistically proven differences were found for: plant height in oxadiargyl, flumioxazine and imazamox; plant diameter at all herbicides tested and doses except isoxaflutol 3.8 g/da; number of inflorescences in all variants treated with herbicides.

13. The linalool content of the Hemus herbicide variants during the first year of the study ranged from 31.1 to 35.3%. For the remaining two years of testing, linolol values are close to the upper limit of the established standard. The content of linalool in the essential oil of the Jubilejna variety in isoxaflutol, oxadiargyl, imazamox and flumioxazine for the study period is 22 to 32.8%, which corresponds to the Bulgarian standard.

14. The values of linalilacetate in isoxaflutol, oxadiargyl, imazamox and flumioxazine for the Jubilejna variety meet the quality standard of lavender oil with values from 30 to 39.6%. In terms of the amount of linalilacetate, the Hemus herbicide variants for the study period are within or close to the standard.

VIII. CONTRIBUTIONS TO THE DISSERTATION

A. Contributions of an original nature

1. For the first time in the country an in-depth study was conducted on the reaction of lavender varieties to a set of herbicides. The susceptibility of the Hemus and Jubilejna varieties to the studied herbicides was established.

2. The efficacy and selectivity of flumioxazine and imazamox in lavender were studied for the first time in Institute for roses and aromatic plants – Kazanlak. The effect of herbicides on plant growth and development was monitored and the tolerance of Hemus and Jubilejna varieties to them was established.

3. As a result of the high efficiency, a positive effect of the herbicides isoxaflutol, oxadiargil, imazamox and flumioxazine applied soil on the growth and economic qualities of the studied varieties of lavender has been proven.

4. It has been shown that the chemical composition of the essential oil obtained from the herbicide-treated isoxaflutol, oxadiargyl, imazamox and flumioxazine plants does not differ significantly from that of the control plants.

5. The influence of soil perspective herbicides on the yield of flower and essential oil of the two studied varieties of lavender has been established.

B. Contributory contributions

1. The biological efficacy of four herbicides in Hemus and Jubilejna varieties has been studied. The good control of the studied herbicides on the weed vegetation is confirmed.

2. The phenological development of the crop after treatment with herbicides, as well as important morphological and economic features were monitored.

C. Scientific and applied contributions

1. New aspects of the application of the herbicides isoxaflutol, oxadiargyl, imazamox and flumioxazine are revealed. Based on a series of comparative experiments, the spectrum of action of the herbicides, the optimal doses and the terms of application were determined.

2. The selectivity of the used herbicides in the varieties of lavender Hemus and Jubilejna has been studied and proved.

Publications in connection with the dissertation:

1. D. Angelova, D., H. Lambev. (2011) Research effect of application of herbicides Raft 400 SC for growing of lavender, Agricultural Science and Technology, Vol.3, №3, pp 235-236, ISSN 1314-412X

2. Angelova, D.,G. Baeva. (2018). Efficacy of some soil herbicides in lavender and their impact on yields color and essential oil, Ecology and Health, Plovdiv, 43-46, ISSN 2367-9530

3. Angelova D. (2019). Influence of soil herbicides on the biometric indicators of lavender, Bulgarian journal of Crop science, Vol. 56 (5)

SUMMARY

During 2011-2015 field trials were carried out the Institute for roses and aromatic plants, Kazanlak on a meadow – cinnamon soil. A lavender crops c.v. Jubilejna and Hemus used. The experiments lay rut was randomize block design with four replications. We studied herbicides Merlin 750 WG (750 g/kg isoxaflutole), Raft 400 SC (400 g/l oxadyargyl), Pulsar 40 (40 g/l imazamox) and Pledge 50 VP (500 g/kg flumioxazine) applied in soil before lavender vegetation.

The objective of the study was the efficiency and selectivity tested to be determined being applied of optimal and 150 % increased doses.

In weed associations in lavender predominate species of the group of dicotyledonous winter-spring and late – spring and less in the group of early spring. From perennial weeds presents root sucker weeds and rhizome weeds.

A high biological efficiency (83-93%) of the studied herbicides was reported in relation to the reported annual weeds.

During the research period, the herbicides that were used have obtained a higher yield of fresh flowers compared to the control on an average for 65 to 170 kg/da.

With regard to the amount of lavender essential oil obtained, it was found that the studied herbicides exceeded the control on average by 1 to 3,4 kg/da, and the results were statistically proven.