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FACULTY OF AGRONOMY

"THE ENVIRONMENT - RESEARCH, CHARGE, ADMINISTRATION"

VOL. 4/2024

COORDINATOR
MARIANA NICULESCU

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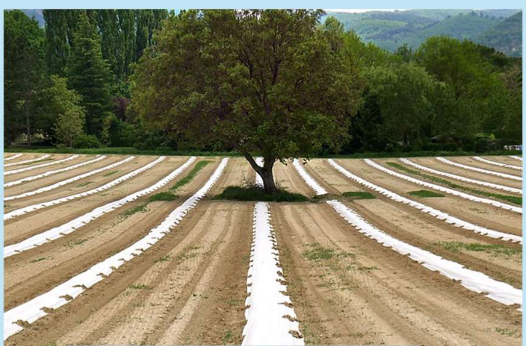

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OMOFAUNA IN THE AGROCENOSIS ON THE WINTER OILSEED RAPE IN THE SHUMEN DISTRICT, NORTHWESTERN BULGARIA

Desislava MITEVA, Ivan IVANOV, Veselin ARNAUDOV

Konstantin Preslavsky University of Shumen, Faculty of Natural Sciences,
Department of Plant Protection, Botany and Zoology,
115 Universitetska Str., 9700 Shumen, Bulgaria
E-mail: 2322291061@shu.bg
2322291075@shu.bg
v.arnaudov@shu.bg
Corresponding author: 2322291075@shu.bg

ABSTRACT

Winter oilseed rape is an important strategic agricultural crop for the Bulgarian economy. The cultivation of this culture is accompanied by a number of difficulties, one of which is its protection from economically important pests. In the period 2022-2023, research was carried out with the aim of identifying the harmful entomofauna in the agrocenoses of winter oilseed rape in the region of Shumen, Northeastern Bulgaria. The study was conducted in an experimental field of the Agricultural Experiment Station - Khan Krum. Samples were collected using the classical entomological methods – metric frames, mowing with an entomological bag, and visual examinations of 100 plants throughout the growing season of the crop. As a result of the study, 21 species of phytophagous insects belonging to 5 orders and 10 families of the class Insecta - Coleoptera, Lepidoptera, Hemiptera, Hymenoptera and Diptera - were found in the rapeseed agrocenoses. Coleoptera was the richest in species (14 species) and the most numerous order (785 specimens on average per year), representing 84.5% of the total number of all harmful insects. In the order Coleoptera, the richest in species and the most numerous are the families Chrysomelidae (6 species) and Curculionidae (7 species), representing 43.9% of the entomofauna of all coleopteran species. Meligethes aeneus L., Epicometis hirta Poda, Psylliodes chrysocephala L., Ceutorhynchus assimilis Payk. and Dasineura brassicae Winn. were one of the most common and most numerous phytophagous insect species in the agrocenoses of winter oilseed rape in the region of Shumen, Northeastern Bulgaria.

Key words: *winter oilseed rape, pest entomofauna, Bulgaria*

INTRODUCTION

Oilseed rape (*Brassica napus* L.), also known as canola, is a major oilseed crop. This crop is grown in more than 32 countries in the world and accounts for 40 to 50% of the total consumption of vegetable oils. Canola is an important crop in many parts of the world as a source of oil, feed, and later as a feedstock in the production of biodiesel Spaar (2006).

The great demand for rapeseed on the European and world markets, as well as the suitable soil and climate conditions for its cultivation in Bulgaria, necessitate the cultivation of this plant as the main technical crop. Initially, it was grown only in Northern Bulgaria, in the valley of the Yantra River and in many parts of the Veliko Tarnovo region, and later in many areas of Southern Bulgaria.

The areas sown with canola in many countries of the world, including in Bulgaria, are constantly increasing. The harvested areas with rapeseed in our country in 2020. are 119,137 thousand hectares, and in 2021 they grew to 130,809 thousand hectares, which is an increase of 9.8% compared to the previous year. In 2021, 372.1 thousand tons of rapeseed were produced in the country, which is 34.4% more compared to the previous year 2020 (Agrarian Report `2022).

Studies of the species composition of rapeseed enemies in different parts of Europe began in the 1980s due to the growing interest in this crop. Depending on the region of cultivation and the type of cultivated oilseed rape, in the parasitocenosis of rapeseed, from 19 to 63 species of phytophages have been identified, and complexes of dominant pest species have been identified that damage the crop in different phases of its development.

In Europe, the most common pests of oilseed rape are pollen beetles (*Meligethes aeneus* Fabr., *M. viridescens* Fabr.), cabbage seed weevil (*Ceutorhynchus assimilis* Payk.), cabbage stem weevil (*Ceutorhynchus pallidactylus* Panz.), rape stem weevil (*C. napi* Gyllenhal), brassica pod midge (*Dasineura brassicae* Winn.), cabbage stem flea beetle (*Psylliodes chrysocephala* L.) and flea beetles (*Phyllotreta nemorum* L., *P. undulata* Kutschera, *P. diademata*) (Free, Williams, 1978, 1979; Ekbom, Borg, 1993; Williams et al., 2002; Hansen, 2003; Ursache et al., 2017; Trotuș et al., 2020, 2022). In the absence of control, these pests are able to reduce the yield by 20-30% (Churikova and Silaev (2010), and some of them, such as the rape pollen beetles (*Meligethes aeneus* F.) and up to 80% (Coll et al. 1998).

In Bulgaria, information on the composition and structure of the harmful entomofauna in the rapeseed agrocenoses is too scarce and limited and only provides insight into certain areas in the southern parts of the country (Palagacheva, 2010; Palagacheva and Dimitrov, 2011; Dimitrov et al. 2013).

MATERIAL AND METHODS

The research was carried out in an experimental test field of the Agricultural Experiment Station - Khan Krum, in the region of Shumen, North-Eastern Bulgaria in 2021-2023 with the aim of collecting insects from the harmful entomofauna of rape culture and their identification. The species composition of pests was determined using the standard methods known in entomological science - metric frames, mowing with an entomological bag and visual examinations of 100 plants. The collected biological material from phytophagous insects was analyzed using a stereomicroscope, after which it was determined and classified systematically. All samples collected are presented as the number of individuals per individuals/m2 or 100 plants, and the aphids found as a percentage of attacked plants (colonies).

RESULTS AND DISCUSSION

As a result of the research carried out in 2021–2023, 21 species of phytophagous insects (929 specimens per year on average) were found in the crops of winter oilseed rape in the area of the city of Shumen. (Table1). The collected insects are systematically classified into 5 orders – Coleoptera - 14 species, Lepidoptera - 1 species, Hemiptera - 4 species, Hymenoptera - 1 species, Diptera - 1 species belonging to 10 families.

Coleoptera is the richest order of insect species (14 species), with the most specimens (785 specimens per year on average), which represents 84.5% of the total number of all harmful insects. (Table. 1). According to the structure of the species collected by family, it is evident that the family Chrysomelidae and Curculionidae are the richest in species, with 6 and 5 species respectively, followed by the family Pentatomidae and Aphididae, with 2 species

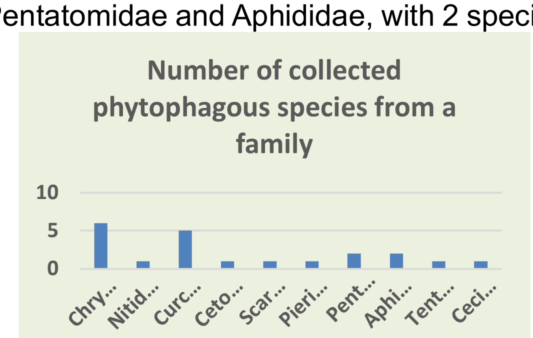

Fig. 1. Number of collected phytophagous species belonging to one family in the rapeseed agrocenoses in the area of Shumen

	Species	Average number of pests		
		2021-2022	2022-2023	Average number/ 2021-2023
I.	**COLEOPTERA**			**785**
1.	**Chrysomelidae**			**195**
	Phyllotreta atra Goeze	54	22	38
	Psylliodes chrysocephala L.	113	97	105
	Phyllotreta undulata Kutsch.	37	15	26
	Phyllotreta nemorum L.	18	8	13
	Phyllotreta nigripes Fabr	6	2	4
	Entomoscelis adonidis Pall.	12	6	9
2.	**Nitidulidae**			**228**
	Meligethes aeneus L.	238	218	228
3.	**Curculionidae**			**213**
	Ceutorhynchus assimilis Payk.	56	132	94
	Ceuthorynchus napi Gyll.	27	85	56
	Ceuthorynchus pallidactylus Marsham	19	67	43
	Ceutorhynchus picitarsis Gyll.	3	5	4
	Lixus sp.	9	23	16
4.	**Cetoniidae,**			**33**
	Oxytirea funesta Poda	17	49	33
5.	**Scarabaeidae**			**116**
	Epicometis hirta Poda	97	135	116
II.	**LEPIDOPTERA**			**11**
1.	**Pieridae**			**11**
	Pieris brassicae L.	9	13	11
III.	**HEMIPTERA**			**22**
1.	**Heteroptera; Pentatomidae**			**14**
	Euridema ornata L.	6	10	8
	Eurydema oleracea L.	4	8	6
2.	**Sterrnorhynha; Aphididae**			**8**
	Brevicoryne brassicae L.	5	7	6*
	Mysus persicae Sulzer	2	2	2*
IV.	**HYMENOPTERA**			**48**
1.	**Tenthredinidae**			**48**
	Athalia rosae L	56	40	48
V.	**DIPTERA**			**63**
	Cecidomyiidae			**63**
	Dasineura brassicae Winn.	78	48	63**
	TOTAL			**929**

Table 1. Species composition and population numbers of phytophagous insects in rapeseed crops in the region of Shumen in 2021-2022 and 2022-2023

*Colonies ** Damaged pods

According to the abundance of the collected phytophagous insects of one order, Coleoptera is the order with the largest share in rapeseed agrocenoses - 785 specimens (84.5%), followed by Diptera with 63 specimens (6.8%), Hymenoptera – 48 specimens (5.1%), Hemiptera – 22 specimens (2.4%), Lepidoptera – 11 specimens (1.2%) (fig. 2).

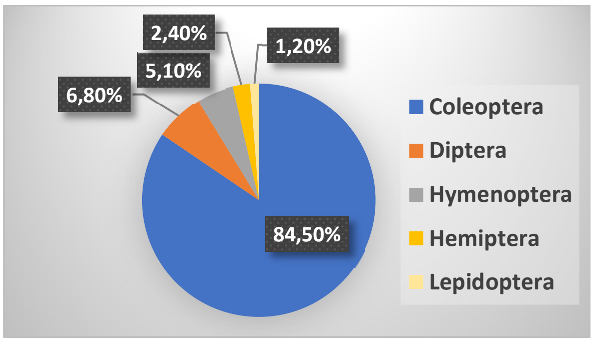

Fig. 2. The abundance of the collected phytophagous insects of one order in the rapeseed agrocenoses in the region of Shumen.

According to the abundance of collected samples of phytophagous insects of the same species, it is found that the most numerous among the harmful species are the pollen beetles (*Meligethes aeneus* L.) with 228 specimens, the blossom feeder (*Epicometis hirta* Poda) with 116 specimens, the cabbage stem flea beetle (*Psylliodes chrysocephala* L.) with 105 specimens, the cabbage seed weevil (*Ceutorhynchus assimilis* Payk.) with 94 specimens and the brassica pod midge (*Dasineura brassicae* Winn.) with 63 specimens, and the least numerous – Cabbage stink bugs (*Euridema ornata* L.) and (*Eurydema oleracea* L.), respectively with 8 and 6 specimens, *Phyllotreta nigripes* Fabr. and *Ceutorhynchus picitarsis* Gyll., each with 4 specimens.

In this study, an attack by two species of aphids *Brevicoryne brassicae* L. and *Myzus persicae* Sulzer was recorded in density, respectively – 6 and 2 colonies per 100 plants (Table 1).

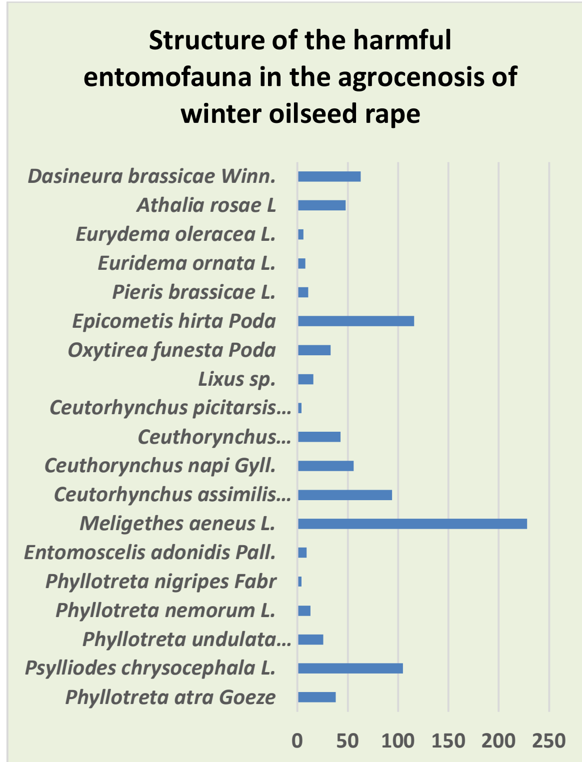

Fig. 3. Structure of the harmful entomofauna according to the number of specimens collected from one species in the rapeseed agrocenoses in the area of Shumen

CONCLUSIONS

As a result of the conducted research, the following conclusions can be drawn.

Winter canola is a suitable habitat for a large number of harmful insect species. In rapeseed crops in the region of the city of Shumen, North-Eastern Bulgaria, the harmful entomofauna is represented by 21 species of insects (annual average 929 specimens), belonging to 5 orders and 10 families.

The two families Chrysomelidae (6 species) and Curculionidae (5 species) of the order Coleoptera are the most abundant in species, while the other families and orders are represented by only 1-2 species each.

The species *Meligethes aeneus* L. with 228 specimens, *Epicometis hirta* Poda (116 specimens), *Psylliodes chrysocephala* L. (105 specimens), *Ceutorhynchus assimilis* Payk. (94 specimens) and *Dasineura brassicae* Winn. (63 specimens) were one of the most common and most numerous species, compared to the species *Euridema ornata* L. (6 specimens), *Eurydema oleracea* L. (6 specimens), *Phyllotreta nigripes* Fabr. and *Ceutorhynchus picitarsis* Gyll. (with 4 specimens each), which were rare and in lower numbers.

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MOUNTAIN PRODUCTS IN ROMANIA – STUDY REGARDING THE IMPLEMENTATION OF THE NATIONAL QUALITY SCHEME IN THE AGRI-FOOD FIELD

Alexandra Gabriela ȘOMÎCU[1], Marius VLADU[2]

[1]*University of Agronomic Sciences and Veterinary Medicine Bucharest of Bucharest, 59 Marasti Boulevard, District 1, 011464, Bucharest, Romania, Phone: +40760839393, Fax: +4021318*
[2]*University of Craiova, 19, Libertatii Street, Craiova, 200583, Phone: +40744870085, Fax: +40251418475, Email: mariusvladu@yahoo.fr*
Corresponding author: alexandrasomicu@yahoo.ro

ABSTRACT

Nowadays, consumers are much more informed and demand quality and food safety. Romania is strongly represented in the agri-food field by products with national quality schemes, but not necessarily at the EU level. The certified products with Protected geographical indication, Protected designation of origin and Traditional specialities guaranteed having a very low share in Romania, 0.3% of the total certified products worldwide. National representativeness is based on 4,857 certified products, of which 4,044 are mountain products. The mountain area is vast, comprising more than half of the country's counties. The purpose of the paper is to analyze the implementation of national schemes regarding mountain products in particular, their location and the link with the food category in which they fall (animal sector, vegetable sector, bakery, beekeeping or others).

Key words: *mountain products, EU level, quality schemes, food safety, agri-food field*

INTRODUCTION

In terms of the food sector, consumers are starting to be much more interested in the way of manufacturing, in the ingredients used in the products they consume. In this sense, manufacturers have already started to change their perspective on products, thus supporting a significant increase in products certified with national and international quality schemes.

The national representativeness is consolidated through the 4857 certified products - mountain products have the largest share. Since more than half of Romania is delimited as a mountain area, it involves an impressive number of certified mountain products – 4,044 products of all types, but mostly obtained from milk, meat, vegetables, fruits.

The mountain agri-food economy is a fundamental pillar not only for economic resilience but also for boosting the social and environmental sphere of mountain areas in need of solid economic activities in order to support their population and protect the environment. [1]

Mountain product is a natural product as it is obtained either in an extensive system of agriculture with low chemical inputs, or in organic farming or is a traditional product. [6]

MATERIALS AND METHODS

The purpose of the paper is to analyse the status mountain products certified in Romania between 2017-2023. The analysis perspective will involve organization by county (i.e. 41 counties and Bucharest City).

Regarding the national documents provided by Ministry of Agriculture and Rural Development, they were used The National Register of Traditional Products for each year between the 2005-2022 [2], the National Register of Mountain Products between 2017-2023 [3], [4], The National Register of Products Certified According to Consecrated Recipes between 2014-2023.

This research presents the status of mountain products certified in Romania between 2017-2023.

RESULTS AND DISCUSSIONS

According to the data provided by the public documents of the Ministry of Agriculture and Rural Development, the mountain area is delimited in 948 territorial administrative units divided into 27 counties out of 42. The mountain area is represented by 64% of the counties at the national level. The Carpathian Mountains are located in 6 countries: Czech Republic, Slovakia, Poland, Hungary, Ukraine, Romania and Serbia and they represent the great central mountain system of Europe. 51% of the Carpathian Mountains is located in Romania (91 mountains).

From 2017 until 2024, 4,044 mountain products have been certified according to national legislation (ORDER 174/2021) and European regulation (REG (EU) 2024/1153).

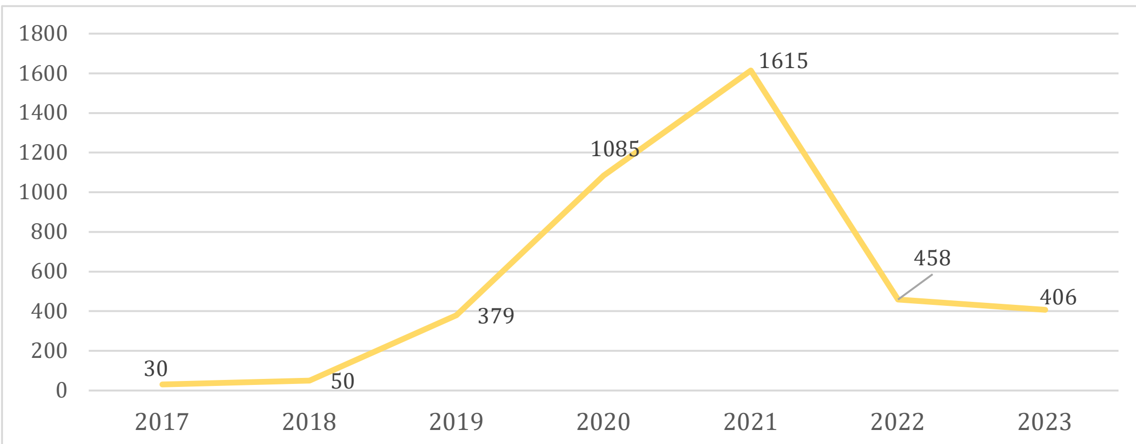

Fig. 1. Status of mountain products between 2017-2023

Source: Own calculation based on the data from [3], [4].

In 2017, 30 products were certified, most of which came from milk (kefir, cheese, curd, sour cream, curd, yogurt, cheese and others) from Covasna and Harghita counties.

A period of slow growth followed with 50 mountain products certified in 2018, with a similar proportion of dairy products and plant products (such as fruit syrups or fir buds). The year 2019 marked a significant increase with an impressive number of 379 certified products. In this case, we are talking about milk products and mostly vegetable products, but many bee products are also introduced, such as (acacia honey and pollen).

In that year, Caraș Severin county stood out with its vinegar products obtained from chokeberry, honey, rose hips, raspberries, apples, gooseberries and black currants.

The year 2020 is noted with a culminating increase of almost 3 times more compared to the previous year. 1085 products from the category of milk, vegetable products, bee products and meat products were certified as mountain products. Fruits and vegetables began to be introduced as mountain products and there is an increase in interest in meat products such as pastrami, bacon, pâté, mostly from pork.

As can be seen from the statistical data, there is an upward trend from 2017 to 2021, which does not stop here. The year 2021 is characterized by 1615 certified mountain products, including eggs and pastry and bakery products. Next, most

products come from milk or are fruits and vegetables (potatoes, onions, chokeberry, plums, and many others).
The beekeeping sector is becoming increasingly important globally. In the period 2017-2022, 207 mountain products originating from bees were certified. Throughout the year 2023, we had 22 mountain beekeeping products, resulting in a total of 229 certified products to date. With the mention that 1 product was withdrawn through the cancellation procedure by the Ministry of Agriculture and Rural Development.

The last two years of attestation (2022 and 2023) were not necessarily the most important from a statistical point of view, but the interest of producers remains at normal levels, we could say, with a number of 406 mountain products in 2023.
Last year, even if there were fewer products, they had a novelty character on the market of certified mountain vegetable products, being certified zacusca-type products, pickles of horseradish or eggplant and all kinds of fruit jams such as blueberries and cranberries.

Table 1. Status of mountain products and products with national recognition - by county

Crt. Nr.	County	Mountain products	Traditional products + Products with consecrated recipes	Total number of national products
1	2	3	4	5
1	Alba	122	49	171
2	Arad	3	7	10
3	Argeș	63	47	110
4	Bacău	190	4	194
5	Bihor	25	8	33
6	Bistrița Năsăud	622	42	664
7	Botoșani	x*	35	35
8	Brașov	107	173	280
9	Brăila	x*	0	0
10	București	x*	19	19
11	Buzău	21	33	54
12	Caraș-Severin	179	12	191
13	Călărași	x*	0	0
14	Cluj	215	16	231
15	Constanța	x	1	1
16	Covasna	459	23	482
17	Dâmbovița	17	5	22
18	Dolj	x*	4	4
19	Galați	x*	17	17
20	Giurgiu	x*	1	1
21	Gorj	162	9	171
22	Harghita	249	2	251
23	Hunedoara	188	10	198
24	Ialomița	x*	0	0
25	Iași	x*	23	23
26	Ilfov	x*	6	6
27	Maramureș	295	59	354
28	Mehedinți	8	3	11
29	Mureș	77	5	82
30	Neamț	167	29	196
31	Olt	x*	3	3
32	Prahova	44	6	50
33	Sălaj	0	15	15
34	Satu Mare	110	28	138
35	Sibiu	159	35	194
36	Suceava	162	23	185
37	Teleorman	x*	0	0
38	Timiș	3	5	8
39	Tulcea	x*	21	21
40	Vâlcea	345	32	377
41	Vaslui	x*	3	3
42	Vrancea	52	0	52
Total number of products:		**4044**	**755**	**4857**

*x=County that is not in the mountain area according to the List of Territorial Administrative Units in the mountain area - the delimited area according to the National Rural Development Program 2014 – 2020
Source: Own calculation based on the data from [3, 4].

For the fish sector, the analysis begins in 2021 when the first products of this kind were certified, based on a single type of fish - trout (spring or mountain) from the counties of Brasov, Gorj and Bacau.

There were 26 fish-type products certified between 2017 and 2023; the interest being low on the part of consumers, but the limited natural resources must also be taken into account.

Bistrita-Năsăud county leads the list of mountain products at the national level with an impressive advantage: 622 certified products from 2017 to the end of 2023. The next county in the ranking is Covasna with 459 mountain products.On the 3rd place is Valcea county, a predominantly mountainous area, with 345 certified products. The last two counties in the ranking of 5 are Maramures county with 295 products and Harghita county with 249 mountain products.

Sălaj is the only county located in the mountainous area, but which does not yet have any certified product. Arad, Timiș, Mehedinți and Dâmbovița are the counties with the fewest mountain products in the whole country.

CONCLUSIONS

The first 5 counties that assume a total number of 1970 mountain products are Bistrita Nasaud, Covasna, Valcea, Maramures and Harghita. These 5 counties represent almost half of the total mountain products certified at the national level.

The mountain agri-food sector is on the rise and in continuous development. Through the national quality scheme, a mountain product can be certified as having a guaranteed quality, having a strong connection with the location on the map.

Agriculture is the key sector developed in the mountain areas, as it provides food for the local households and communities and also sustaining the mountain economy. [6]

Most of the products certified by quality schemes in Romania have representative elements from the mountain area. An impressive number of 4,044 mountain products are certified until December 2023, especially in correlation with the vast size of the mountain area in Romania (64% of counties).

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RESPONSE OF SOME CHERRY CULTIVARS TO ATTACK OF THE BLACK CHERRY APHID – *MYZUS CERASI* FAB. IN THE CONDITIONS OF CENTRAL EASTERN BULGARIA

Stanislav IVANOV, Vasil VASILEV, Veselin ARNAUDOV

Konstantin Preslavsky University of Shumen, Faculty of Natural Sciences,
Department of Plant Protection, Botany and Zoology,
115 Universitetska Str., 9700 Shumen, Bulgaria
E-mail: 2220120008@shu.bg
2220120012@shu.bg
v.arnaudov@shu.bg
Corresponding author: 2220120008@shu.bg

ABSTRACT

The black cherry aphid (Myzus cerasi F.) is one of the most common and most damaging species of aphids attacking cherry trees in Bulgaria. The response of ten cherry cultivars to attack by M. cerasi was studied under field conditions. The study was conducted under natural conditions of aphid attack, in an industrial cherry orchard in the vicinity of Dulgopol, Central Eastern Bulgaria, in the period 2022-2023. Leaf rosettes of each variety infested with aphids were examined and scored for the degree of attack by this pest. The reaction of each cultivar was evaluated according to the calculated infestation index, and the individual cultivars were classified according to the degree of sensitivity. The results show that none of the studied cherry cultivars showed complete resistance to attack by M. cerasi. A wide variability was found in the responses of individual cultivars. Some of the cultivars such as 'Bigarreau Burlat' and 'Bigarreau Moreau' cultivars, are very highly susceptible, while others cultivars as 'Rivan' and 'Stella' - slightly susceptible to attack by this pest.

Key words: *sweet-cherry, cultivars, black cherry aphid, attack*

INTRODUCTION

The black cherry aphid (*Myzus cerasi* F.) is a common pest in many countries of Europe, including Bulgaria, as well as in other parts of the world such as Asia, Australia, New Zealand and North America (Dixon, 1985; Andreev at al., 2008; Rakhshani, 2014; McLaren and Fraser, 2002).

In Bulgaria, this aphid species appears every year and causes serious damage to cherry trees. Aphids, when fed, release toxins that, which cause strong curling of the leaves, blocking of the growth of the shoots and severe deformations. In addition to direct damage, aphids also cause indirect damage by releasing honeydew, which contaminates the leaves and reduces their photosynthetic activity. Heavily attacked trees have suppressed growth, a smaller number of fruit buds and a greatly reduced yield. The fruits of the infested trees are often contaminated with excrement and larval skins, which negatively affects their commercial appearance and quality.

Information on the resistance of cultivated cherry cultivars to attack by *Myzus cerasi* is too scarce and limited (Arnaudov, 2006; Arnaudov and Kolev, 2009; Głowacka & Rozpara, 2015). Arnaudov and Kolev (2009) reported 10 cherry varieties with different susceptibility to the black cherry aphid, each colonized to a greater or lesser extent.

Worldwide studies on the resistance of cherry cultivars and hybrids to attack by *Myzus cerasi* show wide variability in their responses: some cultivars are susceptible and others less susceptible to attack by this species of aphid (Stefanova and Malchev, 2020).

The aim of the present study was to investigate and compare the response of several cherry cultivars to attack by the black cherry aphid *Myzus cerasi* F. under the ecological conditions of Central Eastern Bulgaria.

MATERIAL AND METHODS

The response of some cherry cultivars to attack by *M. cerasi* F. was studied under field conditions. The study was conducted under natural conditions of aphid's attack, in an 11-12-year-old industrial cherry orchard in the Dulgopol region, Central Eastern Bulgaria, in the period 2022-2023. The subject of the study was 10 cherry cultivars 'Bigarreau Burlat', 'Bigarreau Moreau', Van', 'Bing', 'Hedelfinger', 'Star crimson Cherry', 'Lambert', 'Lambert' 'Sunburst', 'Sunburst', 'Rivan' and 'Stella', all grafted on rootstock Prunus mahaleb L. The trees were planted in 6 x 5 m row orientation; 10 replicates per cultivar. No insecticide treatments were carried out during both years of the study.

The level of *Myzus cerasi* populations was assessed every year in the first half of May, before the end of the third fundatrix generation (before the appearance of the first winged forms).

For this purpose, 100 leaf rosettes (10 rosettes from 10 trees) were examined per tree for each variety. All rosettes with visible aphid colonies were scored separately for each tree and cultivar to determine the population level. Depending on the number of rosettes attacked and the number of aphids in them, the leaf rosettes were classified on a 7-point scale:

Class 0: leaf rosettes without aphids;
Class 1: from 1 to 5 aphids in a rosette;
Class 2: from 5 to 20 aphids in a rosette;
Class 3: from 20 to 50 aphids in a rosette;
Class 4: from 50 to 100 aphids in a rosette;
Class 5: from 100 to 200 aphids in a rosette;
Class 6: more than 200 aphids in a rosette.

Susceptibility of cultivars to attack by *M. cerasi* was evaluated and compared according to the infestation index of the leaf rosettes, calculated as a percentage according to the formula of McKinney (1923). All studied cultivars were classified into 5 different levels of susceptibility to attack by *M. cerasi* based on the calculated infestation index:

Class 0 - resistant cultivars - 0 % infestation index;
Class 1 - slightly susceptible cultivars - 0.1 to 0.9% infestation index;
Class 2 - susceptible cultivars – from 1 to 2.9 % infestation index;
Class 3 - highly susceptible cultivars - from 3 - 4.9% infestation index;
Class 4 - very highly susceptible cultivars - more than 5% infestation index

Data were statistically processed by Duncan's test (Steele & Torrie, 1980).

RESULTS AND DISCUSSION

The black cherry aphid *Myzus cerasi* F. is an annual pest in the cherry orchards of Dulgopol.

Hatching of M. cerasi nymphs in this region usually begins in late March, when cherries are in the "bud burst" phenophase, and lasts about a week. In 2022 the first nymphs were registered on 22.03, and in 2023 – about a week later, on 28.03. Due to their small size and low population numbers, aphids are very difficult to detect during this period. Young nymphs are most often found on the green parts of open buds, sucking juice from them. In April, during flower bud separation and first leaf emergence, aphids were observed gradually migrating along the underside of leaves, settling near the midvein as well as on pedicels of blossoms. A week later ("mass flowering" phenophase), stem mothers, completing their development, turned into wingless parthenogenetic females and began to give birth to nymphs, giving rise to the next fundatrix generation.

By late May and early June, the species developed two more parthenogenetic generations, which were significantly more numerous than the first.

Inspections made at the beginning of June showed that *Myzus cerasi* F. occurs in the crowns of trees of almost all studied varieties, but not in equal numbers (Table 1). This pest was found most frequently and in the highest density in the crown of trees of 'Bigarreau Burlat' and 'Bigarreau Moreau' cultivars, infestation index 5.41 and 5.26%, respectively. Following them in terms of attack rate are 'Van', 'Bing', 'Hedelfinger' and 'Star crimson Cherry', infestation index varying between 3.80 and 4.84% on average, followed by 'Lambert' and 'Sunburst', infestation index of 1.31 and 1.24%, respectively. Weakest attack by *Myzus cerasi* F. was recorded in 'Rivan' and 'Stella' cultivars, infestation index varying from 0.35 to 0.48%.

Table 1. Response of some cherry cultivars to attack of *Myzus cerasi* Fab. in the period 2022-2023, Dulgopol, Central Eastern Bulgaria

Cultivar	The infestation index of *Myzus cerasi* Fab., by McKinney		
	Year		Average
	2022	2023	2022-2023
'Bigarreau Burlat'	5.57	5.24	5,41 a*
'Bigarreau Moreau'	5.36	5.16	5,26 a
'Bing'	4.96	4.71	4,84 aв
'Van'	4.60	4.54	4,57 aв
'Hedelfinger'	4.12	3.96	4,04 в
'Star crimson Cherry'	3.93	3.67	3.80 в
'Lambert'	1.44	1.18	1.31 c
'Sunburst'	1.36	1.12	1,24 c
'Rivan'	0.50	0.45	0.48 d
'Stella'	0.42	0.28	0.35 d

*The means followed by the same letter do not differ significantly from one another (p = 0.05).

The results of the research show that there are no cultivars that are completely resistant to attack by *Myzus cerasi*. It is important to note that not all studied cultivars are equally susceptible to attack by this pest.

Summarizing the results of the research, we can conclude that 'Bigarreau Burlat' and 'Bigarreau Moreau' cultivars, are very highly susceptible, 'Van', 'Bing', 'Hedelfinger' and 'Star crimson Cherry', are highly susceptible, 'Lambert' and 'Sunburst', are susceptible, and 'Rivan' and 'Stella' - slightly susceptible to attack by *M. cerasi*.

The results obtained in this study are very close to those reported by other authors in a previous period. They reinforce the view that not all cherry cultivars are equally susceptible to attack by the black cherry aphid, *Myzus cerasi* Fab. Some of them such as 'Bigarreau Burlat' and 'Bigarreau Moreau' cultivars are very highly susceptible, while others cultivars as 'Rivan' and 'Stella' are slightly susceptible to attack by *M. cerasi*.

At this stage of research, it is difficult to give an explanation for this phenomenon. These differences in the susceptibility of individual varieties may be due to differences in the biochemical composition of the leaves, as well as to the unequal vigorous of the trees, which is specific to each variety and in most cases is not influenced by the habitat and growing conditions. These questions are interesting and important for selection and practice, but they were not the subject of the present study.

CONCLUSIONS

- None of the studied cultivars was completely resistant to *M. cerasi* infestation.
- The cherry cultivars did not show the same degree of susceptibility to attack by *M. cerasi.*
- 'Bigarreau Burlat' and 'Bigarreau Moreau' cultivars, are very highly susceptible, 'Van', 'Bing', 'Hedelfinger' and 'Star crimson Cherry', are highly susceptible, 'Lambert' and 'Sunburst', are susceptible, and 'Rivan' and 'Stella' - slightly susceptible to attack by *M. cerasi*.

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PLANT PROTECTION MEASURES AGAINST WEEDS IN POPLAR FOREST PLANTATIONS

Vasil VASILEV, Stanislav IVANOV, Filip FILIPOV, Dimcho ZAHARIEV

Konstantin Preslavsky University of Shumen, Faculty of Natural Sciences,
Department of Plant Protection, Botany and Zoology,
115 Universitetska Str., 9700 Shumen, Bulgaria
E-mail: 2220120012@shu.bg
2220120008@shu.bg
2320120004@shu.bg
d.zahariev@shu.bg
Corresponding author: 2220120012@shu.bg

ABSTRACT

The creation of forest plantations provides benefits in various directions: economy, ecology and environmental protection. One of the most widespread forest plantations along the banks of the rivers in Bulgaria are those of various branches of poplars. Poplar habitats are characterized by high humidity and rapid development of unwanted grass, shrub and tree vegetation. Due to the rapid rate of development of weed species, this vegetation can actually threaten the existence of the poplar forest culture. The different groups of weed species are presented. The advantages and disadvantages of the methods used to control weed vegetation are discussed. A specific feature of growing poplar forest plantations is the implementation of plant protection against weeds mainly through agrotechnical measures and minimization of chemical control methods.

Key words: *competitive plants, invasive plants, methods for control, ruderal plants*

INTRODUCTION

Wood is one of the oldest natural resources used by humans. Quite naturally, its use increases proportionally with the increase in the number of people. This necessitates the need to find new sources for its production. One solution is the creation of intensive forest crops of fast-growing species. For the climatic conditions of Bulgaria, poplars (*Populus* sp. diversa) are one of the fastest growing tree species.

The establishment of forest plantations provides benefits in various directions: economy - creation of employment (Freer-Smith et al., 2019) and income from timber extraction, ecology - restoration of biodiversity during land reclamation (Society for Ecological Restoration International Science and Policy Working Group, 2004), environmental protection - protecting lands from water or wind erosion (Facciotto et al., 2014), replacing non-renewable energy sources with renewable ones (Hetemäki et al., 2017), replacing plastic packaging with paper ones (Berg & Lingqvist, 2019), reducing the carbon footprint (Arevalo et al., 2011, Sathre & O'Connor, 2010, Werner et al., 2012).

Growing fast-growing forest plantations requires less land than natural forests (Warman, 2014). For this very reason, it is possible that forest plantations start to be grown on the territory of natural forests, as they are economically more profitable in the short term (Cubbage et al., 2007). There are already examples in this regard in Bulgaria. A widely applied practice, both along the Danube River and in the interior of the country, is the cultivation of intensive poplar crops (mainly from *Populus* x *euroamericana* cv. I-214). In some cases, these forest plantations were created in place of natural willow-poplar forests (Tzovev & Dimitrov, 2011). We hope that reason prevails in this competition, as natural forests are the source of many more ecosystem services than forest plantations.

The first attempts to grow poplars in Bulgaria date back to the 1970s along the Danube River. The main poplar branches used in the

20th century in Bulgaria are: *P.* x *euramericana*, *P. deltoides*, *P. interamericana*, *P. alba*, *P. canescens*, *P. simonii* (Tsanov & Mikov, 1997). Today, the following poplar branches are cultivated in Bulgaria: *P.* x *eur.* cv. I – 214, *P.* x *eur*. cv. I - 45/51, *P*. x *eur*. cv. BL, P. Welthaimaipapel, *P*. x *eur*. cv. Agathe F, *P*. x *eur*. cv. MC, *P. deltoides* I - 55/65, *P. deltoides* A – 194, *P*. x *eur*. cv. I - 39/61, *P*. x *eur*. cv. I - 37/61, *P*. x *eur*. cv. Bachelieri, *P*. x *eur*. cv. Panonnia (M1), *P*. *rodusta* R – 16, *P*. x *eur*. cv. CB – 7, *P*. x *eur*. cv. NNDV, *P*. x *eur*. cv. Guardi, *P*. x *eur*. cv. Luiza Avanzo, *P*. x *eur*. cv. B 12, *P*. x *eur*. cv. Guardi, *P.* x *eur*. cv. NNDV, *P*. x *eur*. cv. Belloto, *P.* x *eur*. cv. Sima, *P.* x *eur*. cv. Simoni, *P*. x *eur*. cv. Vernirubens, *P. nigra* (Activities Related to the Cultivation and Utilization of Poplars, Willows and other Fast-growing Trees 2016-2019, 2020).

According to the forest vegetation zoning of Bulgaria (Tsanov & Mikov, 1997; Mikov et al., 2011), poplar habitats are divided into 3 main groups:

1. Poplar habitats along the Danube River (floodplains): Danube willow-poplar (transitional) habitat, Danube typical poplar habitat, Danube drained habitat, Danube drained poplar habitat.
2. Riparian poplar habitats along the banks of inland rivers: riparian willow-poplar, riparian typical poplar, riparian drained poplar, riparian conditional poplar, riparian low mountain habitat.
3. Non-fluvial (atypical) poplar habitats: non-fluvial valley, non-fluvial plain, non-fluvial slopes.

According to Ordinance No. 2 of February 7, 2013 on the terms and conditions for afforestation of forest territories and agricultural lands used to create special, protective and economic forests and forests in protected territories, inventory of created crops, their reporting and registration (Chapter VII , Section I) forest crops are grown with the aim of creating optimal conditions for the growth and development of planted tree and shrub species at the youngest age, maintaining them in good health, regulating the composition of the crop and creating conditions for the production of high-quality wood. Cultivation of forest crops consists of conducting activities in the inter-rows and in the rows.

The recommended scheme that best performs the conditions for production of large poplar timber is described as a hexagonal shape in the planting areas. The advantages of this scheme are that it provides uniform growth space in all directions and cylindrical stems with the same density of wood are formed. On the typical poplar and drained poplar habitats along the inland rivers and drained habitats, where the goal is to extract large wood, the large-crowned poplar cultivars are planted at a scheme of 6x6 m in a square order and 6 x 5.20 m in a hexagonal order of the planting sites and narrow-crowned cultivars - at 5 x 4.33 m in a hexagonal scheme and 5 x 5 m in a square scheme. In case of intermediate use, a rectangular scheme 6 x 3 or 5 x 3 m is applied and a diagonal thinning of 50% is envisaged. In this case, by the 8th year, an intermediate felling is done through a tree in the row for extraction of medium wood, after which the other individuals are for extraction of large wood. For medium wood (of atypical poplar habitats) the suitable planting schemes are 4 x 4, 4 x 3 and 3 x 3 m when using narrow-crown cultivars. In other habitats, the 5 x 4 and 4 x 3 m schemes are most often used. Crop types are only pure. Willow crops for production of timber are created at a density of 3 x 3, 3 x 4 to 4 x 4 m, and for protective purpose at a density of 1 x 2 and 2 x 2 m. In recent years, for various reasons we were given freedom of choice and practical changes on places. In practice, a few years ago the prevailing density in the poplar plantations was 5 x 4 m, with a wide variety of other densities ranging from 3 x 3 m to 5 x 6 m. Schemes with interim use and careful and slower thinning of plantations were avoided. Gradually, these tendencies are changing and report positive practices about the increase of the share of the plantations in the square schemes depending on the habitus of the crown. In this respect there are practices for specialized plantations of narrow crown poplars from the type - linear and group afforestation (Activities Related to the Cultivation and Utilization of Poplars, Willows and other Fast-growing Trees 2016-2019, 2020).

Ordinance No. 2 of February 7, 2013 also regulates the conduct of activities in the rows of forest crops. The number of activities during the year for intensive poplar crops varies from 3 to 5 activities. Row activities include: ploughing, harrowing, cultivating, milling, mulching, weeding, mowing and hoeing to remove or limit weeds, grasses, shrubs and other competing vegetation. Activities in the interrow are carried out in the following ways:

1. Ploughing, cultivating, harrowing, milling and mulching.
2. Mowing or shallow hoeing of weedy, grassy, shrubby and coppice vegetation.
3. Felling or cutting of shoots, unwanted undergrowth, competitive and disease- and pest-damaged vegetation, including their removal from the area or burning if necessary.
4. Agricultural use with trench crops. E.g. corn, potatoes, watermelons and peanuts. This method of cultivation is applied in the presence of rich soils and larger inter-row distances. The distance between the saplings and the trench culture should be no less than 50 cm.
5. Spraying with selective herbicides and arboricides, plant protection preparations, repellents and liming the stems.

In case of mechanized cultivation of the crops, a protective strip with a width of 10 to 30 cm is left between the saplings and the cultivated area.

The following relationships (coexistence) are permissible when mixing tree and shrub species in forest crops (Regulation No. 2 of February 2, 2009 on afforestation and inventory of forest crops):

1. Plane trees with poplars, willows, and black alder.
2. Poplars with black alder, plane trees and willows.
3. Black alder with willows, poplars and black walnut.
4. Willows with poplars, black alder and plane trees.

These coexistences are suitable for three of the four main categories of afforestation:

1. Commercial afforestation - to create forests for the production of wood, biomass, seeds, Christmas trees, technical products and fruit.
2. Protective afforestation - to create protective and water protection forests.
3. Landscape afforestation - to create recreational forests in resort areas and localities, rural forest parks, as well as to improve the landscape along main transport highways, around cultural monuments and natural attractions.
4. Experimental afforestation - to create forests with experimental and scientific purposes.

The mixing of tree and shrub species in forest crops is not suitable for economic afforestation, which is aimed at wood extraction.

According to Kovacevic (1979, based on Vasic et al., 2012) the weeds in forestry are all herbaceous plants, shrubs, and trees which, in forest nurseries, stands, and clear-felled areas weaken or prevent the growth and development of cultivated trees.

According to Vajda (1983, based on Vasic et al., 2012), weeds in forestry are classified as beneficial or harmful. Weed control results in increased tree growth, but weeds in forestry are not always harmful. Weeds prevent soil erosion. Grassy plants that are weeds in forest stands are food for wild animals. The fruits of some bushy and woody weeds are edible by both animals and humans. Many weeds have medicinal properties and are used as medicinal plants. Weeds can provide suitable shelters for wildlife and birds. Despite the stated numerous benefits of weeds, they are not desired in forest plantations because weed vegetation can actually threaten the existence of the poplar forest culture.

Konstantinovich (1999, based on Vasic et al., 2012) divided weeds in forests into 3 groups: harmful, indifferent, and useful. Harmful weeds are plants that interfere with the development of trees and form a dense cover. Indifferent weeds are plants that grow separately, form a light cover and do not interfere with the development of trees in forest crops. Useful weeds are plants with medicinal properties and plants that produce fruit.

Regarding the light regime, weeds can also be classified into 3 groups: sciophytes, semisciophytes and heliophytes. Sciophytes are plants that grow in the shade in thinly thinned forest stands or in dense forest stands and do not pose a threat to the development of trees. Semisciophytes are plants that grow in semi-shady places - e.g. in sparse forest stands and can cause moderate damage. Heliophytes are plants inhabiting open and well-lit habitats such as clearings, strips, burned areas, etc., and represent the greatest threat to the development of trees in the first years of their cultivation (Vasic et al., 2012). There are also a number of other classifications of weeds in forestry, such as: weeds of forest nurseries and weeds of forest plantations and forest stands (Vasic et al., 2012).

RESULTS AND DISCUSSIONS

During the preparation for the establishment of the forest plantation, the natural vegetation cover is disturbed. From the preserved vegetative parts, seeds and fruits, some of the species begin to restore their populations. In addition, the vacated space represents a free ecological niche and allows the entry of many species that have not been distributed in this territory until now. As a result, the overall composition and ratio between plant species changes.

On the one hand, the changes are planned as a result of the purposeful introduction of species by man - the main cultivated species and in some cases accompanying species. On the other hand, accidental entry of species from neighboring territories is observed. The most common weed species in forest plantations are: *Ambrosia artemisiifolia*, *Amorpha fruticosa*, *Asclepias syriaca*, *Erigeron canadensis*, *Solidago gigantea*, *Sorghum halepense*, *Sambucus nigra*, *Stenactis annua*, *Pteridium aquilinum*, *Rubus caesius* and others (Vasic et al., 2012). The most dangerous among accidentally invading species are competitive trees and shrubs, ruderal and invasive plants.

Competitive trees and shrubs are those species that have a fast growth, like poplar, and represent strong competition in the first years of the establishment of the crop. Examples of such plants are: *Vitis vinifera* L. (syn. *V. sylvestris* Gmel.), *Clematis vitalba* L., *Sambucus nigra* L., *Rubus* sp. diversa.

Ruderal plants prefer rich and moist soils, and poplar habitats are just that. These plants have fast growth and a large biomass that requires a large amount of nutrients. As a result of favorable conditions, ruderal plants can reach the maximum sizes for the species, which often reach 1.5-2.0 meters. Examples of such plants are**:** *Urtica dioica* L. (with a maximum height of 1,8 m), *Chenopodium album* L. (with a maximum height of 1,5 m), *Arctium lappa* L. (with a maximum height of 1,5 m), *Sambucus ebulus* L. (with a maximum height of 2,0 m), *Cirsium arvense* (L.) Scop. with a maximum height of 1,5 m), *Carduus nutans* L. (syn. *C. thoermeri* Weinm., with a maximum height of 2,0 m), *Rumex crispus* L. (with a maximum height of 1,5 m), *Solanum dulcamara* L. (with a maximum height of 2,0 m), *Galium aparine* L. (with a maximum height of 1,8 m).

Invasive alien species of plants develop successfully on any type of soil, are resistant to adverse climatic conditions, have high vegetative and/or seed productivity, very often form dense groups (in some cases up to hundreds of individuals per 1 sq. m - e.g. the last 3 the types listed below) and possess effective means of dissemination. Examples of such plants from the tree species are: *Ailanthus altissima* (Mill.) Swingle, *Acer negundo* L.; of the shrub species Amorpha fruticosa L. is the most common; of the herbaceous species, the following are most often found: *Sorghum halepense* (L.) Pers. (with a maximum height of 2,0 m), *Solidago gigantea* Aiton (with a maximum height of 2,5 m), *Erigeron annuus* (with a maximum height of 1,0 m), *Erigeron canadensis* L. (with a maximum height of 1,5 m), *Bidens frondosa* L. (with a maximum height of 1,8 m).

As a result, continued control by man is necessary until a community is established in which his chosen crop plants dominate.

Plant species build complex relationships with each other:

1. Competition for major vegetation factors: space, light, water and nutrients (Schenk, 2006). An important factor that leads to rapid changes in vegetation cover is succession. In this process, human intervention is key to the survival of introduced plants. The goal is to obtain a monoculture or combine several crops and minimize the impact of the other plant species. In this respect, the rapid growth of poplar trees is a great advantage.

2. Allelopathic relationships. This is accomplished both by root exudates (Ehlers et al., 2020) and by volatile organic substances released from the aerial parts of plants (Evans et al., 2019).

In chemical control methods, it has been found that there are two forms of herbicide transfer to neighboring plants: intraspecific transfer to other specimens of the species and interspecific transfer to other species. Intraspecific transfer takes place through the underground parts of plants. Neighboring plants in trees and shrubs very often represent a branch - they have a common vegetative origin and preserved connections between them. Thus, they are physiologically related and can share the products of photosynthesis to promote the growth of the entire associated group. There are several theories that explain the transfer of substances between individual plant species: through root contacts, mutually shared mycorrhizal fungi, root exudation and uptake, leaf senescence (Lewis, 2007).

3. Cooperation. Individuals of the same species and also of different species can help each other by exchanging nutrients and information (Wohlleben, 2016).

The goal of weed control in forest plantations is not the complete destruction of weed vegetation, but the reduction of competition with cultivated plants to a level that does not adversely affect their growth. Several groups of methods are used for weed control:

1. Mechanical Methods. It involves physical removal of weeds by methods such as hand weeding or mowing or using machinery such as a chainsaw or brush cutter. Hand weeding was a widely used method in the past to remove weeds from the rows. This is the slowest and most expensive method of weeding. Mowing in the past was also done with a hand scythe. Today, motorized shears are used, which have good performance and are safer for the trees being grown. The application of brush cutters is very limited, since their use is not necessary for systematic mowing. They are used in cases of missed mowing and advanced development of competing shrub and tree species.

Advantages: This is one of the most environmentally friendly methods that cares for the protection of the environment.

Disadvantages: It requires a lot of time and the need to provide more workers. The use of brush cutters can damage the stems of the target crop.

2. Chemical Methods. Herbicides can be used to selectively eliminate weeds while minimizing damage to forest crops. It is important to follow the directions for use and precautions. It should be taken into account that the applied herbicides should not reach the leaves of the cultivated trees. Both liquid herbicides (in the form of a spray applied to the vegetative parts of the weed species) and granular herbicides (applied on the soil surface) can be applied. The most commonly used herbicides in forest plantations are based on **fluroxypyr** or **mesotrione**. The following herbicides are also suitable for use: **Glyphosate** is used for total control of weeds in the intensive growth phase in a concentration of 2-3%. Its efficacy against weeds is high due to good translocation in roots and rhizomes. **Glyphostate** is used to treat stumps to prevent sprouting. The concentration is 10-15% and is applied immediately after cutting, but the treatment can be applied until the emergence of shoots from May to October. **Glufosinate - ammonium** is used as a non-selective, contact herbicide for weed control in forest plantations. It is applied in an amount of 4-7.5 l/ha at a water consumption of 400-600 l/ha. **Triclopyr** is used to combat oak shoots in a ratio of 1:5 or 1:10 for other deciduous species. The best way is to treat the stumps immediately after cutting, but it is possible until the shoots emerge (Vasic et al., 2012).

In New Zealand, a large number of companies that maintain forest plantations applied a mix of **terbuthylazine** and **hexazinone** during the first 2 years of the establishment of the crop (Rolando et al., 2015). The following herbicides are used in Bulgaria: **Glyphostate**, **Oxyflorofen**, **Fluazifop-P-butil** (Bratanova & Stoyanov, 2009).

Advantages: Faster results and lower labor costs. Possibility of local (spot) application only in areas where it is needed, which can reduce costs and chemical impact on the environment. Action that lasts until the end of the growing season.

Disadvantages: Chemical pollution of the environment and negative impact on soil fertility. There is a risk of crop damage when using higher doses. At increased doses, selective herbicides become total and can have a negative effect on cultivated trees.

3. Biological Methods. Introducing natural enemies of weeds, such as insects or pathogens, can help reduce weed populations. This method is often used in combination with other control methods.

Advantages: Environmental protection from chemical pollution. They do not completely destroy weed species, but maintain their abundance in limits below the threshold of economic harm.

Disadvantages: Relatively slow action. Natural enemies of weeds can easily spread outside the forest plantation and negatively impact populations of the plants they attack in natural habitats.

4. Cultural Methods. Practices such as mulching and the use of cover crops give very good results in suppressing weed vegetation composed of herbaceous plants when it comes to perennial crops.

Advantages: Prevents the germination and development of a high percentage of weed seeds.

Disadvantages: This group of methods has very low efficiency in forest crops, including forest nurseries (Owston & Abrahamson, 1984). These measures cannot help to suppress the growth of shrub and woody weed species, and even some fast-growing and larger grassy weeds, and hence cannot reduce their competition with cultivated trees.

5. Integrated weed management. Combining several control methods can result in more effective weed management. At the same time, the negative impact on the environment is reduced. Most often, mechanical and chemical methods are combined.

Advantages: Tree and shrub weed species are very resistant and have a high regenerative capacity, which is why it is difficult to completely destroy them by mechanical means. Here, combining with chemical control methods is crucial.

Disadvantages: The application of each of the methods, despite its combination with other methods, has its drawbacks. It is possible to combine the methods to reduce the degree of impact of their disadvantages, but it is unlikely to eliminate them completely. Integrated weed management has been chosen as the most appropriate for both crop cultivation in agriculture and forest plantations in forestry. According to a technological map of mechanized technology for the creation of poplar plantations in the North-West State Enterprise in Bulgaria, an alternation of mechanical treatments and chemical control is applied according to the following scheme (Marinov et al., 2017):

First year after establishment of the forest plantation:

1. Double (cross) discing between the rows of plants with a disc harrow in the periods 15 May - 25 June and 20 - 28 July.
2. Manual digging around the stems of the plants in the periods 25 May - 30 June and 5 June - 30 July.
3. Application of herbicide in the period 10 - 11 June.
4. Double (crossed) disc harrowing with a disc harrow in the period 15 – 19 October.

Second year after establishment of the forest plantation:
1. Double (cross) discing between the rows of plants with a disc harrow in the periods 15 May - 25 June and 20 - 28 July.
2. Manual digging around the stems of the plants in the periods 25 May - 30 June and 5 June - 30 July.
3. Application of herbicide in the period 10 - 11 June.
4. Double (cross) disc harrowing with a disc harrow in the period 15 - 19 October.
Third year after establishment of the forest plantation:
1. Double (cross) discing between the rows of plants with a disc harrow in the period 10 - 12 June.
2. Manual digging around the stems of the plants in the period 15 - 24 June.
3. Double (cross) disc harrowing with a disc harrow in the period 15 - 19 October.

CONCLUSIONS

Although fast-growing poplar branches are grown in intensive forest plantations, weeds remain one of the biggest challenges in the first years after their planting. The most effective weed control in poplar forest plantations is achieved by applying integrated weed management by alternating mechanical treatments and chemical control. A specific feature of growing poplar forest plantations is the implementation of plant protection against weeds mainly through agrotechnical measures and minimization of chemical control methods. This is especially important given the habitats of poplars, which are most often adjacent to flowing or stagnant bodies of water.

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RESEARCH ON THE COMPARATIVE CULTURE OF SOME SWEET POTATO GENOTYPES CULTIVATED IN SOUTH-WEST ROMANIA

Student: LORENA- MARINELA POPESCU[1]
Scientific coordinator: Assoc. Prof. dr. RODICA SOARE[1]

[1]*University of Craiova, Faculty of Agronomy, Specialization Agriculture*
19 Libertatii Street, Craiova, Romania
Corresponding author: soarerodi@yahoo.com

ABSTRACT

Ipomoea batatas L. belongs to the Convolvulaceae family and is a widespread crop in tropical and temperate regions. China is the top sweet potato producer in the globe, generating 80% of the world supply, followed by Nigeria and Ugand. The species is cultivated for its tuberous roots used in human and animal food, but also as raw material for the pharmaceutical industry. In Romania this species is little known. One of the key factors contributing to the area's poor production, among other factors, is the lack of improved varieties suitable for the growing environment. In this sense, in the South-West of Romania, at The Didactic Research Station of the University of Craiova, in the year 2023, an experience regarding the comparative crop of 3 sweet potato genotypes was initiated. The results showed that the best yield results were registered with Chestnut, of 34.50 root /ha.

Key words: *climate, sweet potato, yield, Ipomoea batatas*

INTRODUCTION

Ipomeea batatas (L.) Lam) or sweet potato belongs to the *Convolvulaceae* family and is a widespread crop species in tropical and subtropical regions. It is cultivated for its tuberous roots used in human and animal food, but also as a raw material for the pharmaceutical industry.

The roots can be consumed boiled, fried, baked or in the form of chips. Due to its high starch content, sweet potato can be used in the alcoholic beverage industry or the food industry to obtain sweet potato flour.

Sweet potato roots have high nutritional value and sensory versatility in terms of taste, texture or pulp color (white, cream, yellow, orange, purple).

Sweet potatoes with purple pulp have an attractive color and high anthocyanin content and are the specialty type in Asia, while those with white-cream pulp are preferred by consumers in the tropics (Truong et al., 2028).

Depending on the color, sweet potatoes contain different concentrations of vitamins, minerals, β-carotene, anthocyanins, phenolic compounds, dietary fiber.

The orange pulp varieties are rich in bio-available beta-carotene, which the body turns into vitamin A and those with purple pulp turn it into antioxidants (Dinu et al., 2020). In addition, the young leaves can be consumed, contain several nutrients and bioactive compounds, are a source of natural antioxidants (Dinu et al., 2018; Soare et al., 2014). But it is the most important root crop, mainly for human consumption.

It can also be used for ornaments and landscapes due to the variety of colors of the leaves and variety of forms or it can remain on the soil as a green carpet (Dinu et al., 2015).

Sweet potato is a species that is highly adaptable to different soil types and irregular rainfall, and guarantees a certain yield even under the most adverse conditions (Egwuonwu and Ozor, 2020).

Sweet potato grows best at average temperatures of 24^0C and is resistant to pests and diseases. The success of sweet potato production depends on numerous factors, such as genotype, pedo-climatic conditions and technology applied.

Selection of varieties with good adaptability to climate and soil conditions is necessary to achieve a high level of production. In a temperate climate, this species is an annual plant.

The optimum temperature for vegetative growth and obtaining a good yield is 20-30^{0}C. Temperatures lower than 10^{0}C negatively affect root development while temperatures above 35oC cause abundant vegetative growth and reduce root thickening.

In Romania, sweet potato is recently introduced into cultivation, especially in the Southern region, on sandy soils. In this regard, in southwestern Romania, at the Didactic Research Station, in 2023, an experience was established on the comparative cultivation of 3 sweet potato genotypes.

MATERIAL AND METHOD

The experience was established in 2023 at the Didactic Research Station of the University of Craiova, Romania (44°18'26"N 23°51'42"E).

The biological material was represented by three sweet potato genotypes: Chestnut, Pumpkin and Italian, resulting in 3 variants. In early spring, the roots were placed for germination on a nutrient substrate, at temperatures of 18-20°C, 2-3 cm between the roots and covered with nutrient substrate 2–4 cm thick.

The shoots obtained were planted on variants, in 3 repetitions, on May 25.

The planting scheme was 1.0 m between rows, and 0.30 m between plants in a row, resulting in 33,300 plants/ha.

Regarding the crop technology, specific works were applied: arranging raised furrows, installing a drip system, mulching the soil with black polyethylene film to maintain heat, prevent weeding, and to prevent the emission of roots in contact with wet soil.

During the vegetation period, two foliar fertilizations with the Cropmax product and preventive treatments against diseases and pests were applied.

Harvesting was carried out 150 days after planting.

At harvest, observations were made on the morphological characteristics of the plants: the total amount of plant material/ha, but also the production characteristics: the average number of tuberized roots per plant, the average weight of roots/plant and the total weight.

The experiment was set up in southwestern Romania, on a brown reddish soil.

This region has a temperate continental climate characterized by the lack of water in the soil and atmosphere and by a diversity of soil types, very important factors for the cultivation of this species (Dinu et al., 2021). Table 1 illustrates the climatic conditions during the experimental period, in southwestern Romania.

Table 1. Rainfall, temperatures and humidity in during the growing period-2023

Month	Temperature (^{0} C)			U of the air (%)	Rainfall (mm)
	min	max	medium		
May	+6.9	+26.7	+15.9	73	53
June	+11.2	+32.9	+20.3	75	116
July	+11.5	+36.5	+25.1	62	57
August	+17.9	+34.2	+26.4	60	-
September	+11.9	+32.8	+21.6	56	21

* https://rp5.ru/Vremea_în_Craiova

RESULTS AND DISCUSSIONS

The morphological characterization has been used for different studies include identification of duplicates, studies for genetic diversity patterns (Vazhacharickal and Augustine, 2024). Sweet potato genotypes can be characterized based on their morphological analysis. The sweet potato stem is cylindrical, has numerous internodes, pubescent or glabrous, and the color varies from green to red-purple, with anthocyanins. The stems are mainly used for vegetative propagation. Thus, in the studied genotypes, the number of stems recorded values from 7.7 to 9.2 stems/layer. In more and less vigorous branches, and Chestnut is characterized by fewer, but strongly developed branches. Some authors (Dinu et al., 2015) reported the stem number / plant, between 7.8 and 8.5, and Zihin et al., (2011) reported the stem number/plant, between 6.5 and 14.1. Regarding the weight stems, this ranged between 0.815 and 1.110 kg/plant (Table 2). It is found that the genotypes with a lower number of branches recorded a higher weight due to their vigor, compared to the genotype with a higher number of branches.The resulting vegetative production can be used in animal feed or for composting. It can be appreciated that vegetative development can be influenced by the genotype and weather conditions.

Table 2.The influence of genotyp on plant growth of sweet potato

Genotyp	Morphological characteristics (medium values)	
	No.stems/ nest	Weight stems (kg/ nest)
Chestnut	7.7	1.110
Pumpkin	7.9	0.943
Italian	9.2	0.815
Average	8.2	0.95

Number of storage root /plant varied depending on genotype, the values were between 4.2 and 5.1, and the average root weight between 0.178 g and 0.240 g (Table 3). Again, it was found that the genotype with a small number of tuberized roots recorded a higher average root weight compared to the genotypes with a large number of tuberized roots/plant.

Tabelul 3. Productivity characters (medium values) of genotyps sweet potato

Genotyp	Productivity characters (medium values)		
	Number of storage root /nest	Average weight root/ (g)	Total production root (t/ha)
Chestnut	4.2	0.240	34.5
Pumpkin	4.6	0.178	27.3
Italian	5.1	0.192	32.4
Average	4.6	0.203	31.4

The average weight of sweet potato tuberous roots is variable and influenced by the genotype. Similar results were reported in other studies conducted in Slovenia, where the average weight of tuberous roots ranged from 332.73 to 428.15 g (Solsar et al., 2016), or in Poland from 0.41 to 0.60 kg (Krochmal Marczak et al., 2018).

The total tuber yield highlighted the Chestnut genotype with 34.5 t/ha followed by the Italian genotype with 32.4 t/ha and the Pumpkin genotype with 27.3 t/ha (Table 3). It can be mentioned from this point of view that yield is a genotype determined characteristic. This could be due to the different tuberization behavior of the potato genotypes or the cultivation area. A study conducted in 2018 at sweet potato in southwest Romania using mulching and non-mulching systems, the total average yield for the three cultivars was 40.05 t/ha for the mulched crop compared to 32.97 t/ha for the non-mulched variant (Dinu et al., 2022).

In some studies, depending on the genotype, yields between 41.6 t/ha and 50.3 t/ha were reported (Dinu et al., 2021), or in southern Oltenia, in Romania, on sandy soils between 20 and 40 t/ha (Diaconu et al., 2018), which recorded yields ranging from 18.52 to 64.62 t/ha (Silva et al., 2011).

Sweet potato yield varies depending on several factors, namely: genotype, cropping system, fertilization system or planting density. Some authors have reported regarding yield per hectare, in the organic system, the yield obtained was about 10,555 kg/ha, in the conventional system 20,000 kg/ha were obtained (Stanciu et al., 2023). Other authors have reported a maximum yield 27907 kg/ha was recorded in the fertilized variant with N150P80K80, when 50000 shoots/ha were planted (Draghici et al., 2017) and Badessa et al., 2024, have reported the highest marketable root yield of 36.40 t ha-1 at 150 DAP.

CONCLUSIONS

The evaluation of morphological and productivity characteristics of some sweet potato genotypes in a given region is important for the expansion of the genotype with good adaptability to pedo-climatic conditions in culture. The total yield of tuberized roots highlighted the Chestnut genotype with 34.5 t/ha followed by the Italian genotype with 32.5 t/ha-1 and the Pumpkin genotype with 23.7 t/ha.

The climatic and soil conditions in south-western Romania allow the optimal development of sweet potato plants and the obtaining of high marketable yields. Through the rich vegetative growth and the appearance and color of the leaves, the sweet potato genotypes also present landscaping potential.

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ECONOMIC AND OENOLOGICAL CHARACHTERISTICS OF NEWLY INTRODUCED VARIETIES COLOMBARD AND UGNI BLANC IN SERBIA

Marija ĐORĐIĆ, Nebojša MARKOVIĆ, Zoran PRŽIĆ
Cooordinating teacher: Zoran PRŽIĆ

Faculty of Agriculture, University of Belgrade, Nemanjina 6, Belgrade, Serbia
Corresponding author: marija.djordjic12@gmail.com and zoranata4@yahoo.com

ABSTRACT

In recent years, new grape varieties have been introduced in Serbia, including the Colombard and Ugni Blanc varieties, which are mainly intended for the production of wine distillates (Cognac and Armagnac). Armagnac is produced in the Armagnac region in the south-west of France, while Cognac has its origins in the French town of Cognac. An important technological difference in their production is that Cognac undergoes two distillation cycles, while Armagnac only undergoes one distillation cycle. Armagnac often contains less alcohol than Cognac, and while Armagnac can take a year to produce, Cognac must be aged for at least two years. Colombard is a French white wine grape variety traditionally grown in Saran and Gascon. It can be found under the synonyms Bardero, Blanc Emery, Blanquette, Bon Blanc.
Ugni Blanc is an Italian white wine grape variety, mainly grown in France and Italy. It known under the synonyms White Shiraz, Bouan and Trebbiano. Both varieties are cultivated for the production of Armagnac and Cognac, and in production of wine, which is used for blending with less acidic wines due to its high acidity. The wines of these varieties are characterized by the aroma of lemon and peach with a hint of grapefruit and delicate floral notes. The experiments were carried out in a vineyard on southern slopes of Fruška Gora (GPS N 45°07'19'' and E 19°51'28'').
The vineyard with a planting distance of 1.5 m between rows and a row spacing of 0.9 m. The training form is Gyot. For research purposes, 10 representative, randomly selected trunks were marked and mixed pruned, leaving one spur with two and one arch with eight buds.
During the vegetation period following parameters were determined: the mass of shoots removed by pruning, the yield, the mechanical composition of the bunches and berries and the qualitative parameters of the grape juice expressed by content of accumulated sugar and the total acids expressed as tartaric acid (g/l). The Colombard variety was more abundant at the studied site, taking into account that a greater mass of shoots discarded during pruning was observed.
A significantly higher average yield of grapes (2,308 kg/trunk) was determined for the Ugni Blanc variety than for the Colombard variety (1,967 kg/trunk). Based on the mechanical parameters of the bunch and the berry (weight of the bunch - 282.4 g, average number of berries in a bunch - 166.8, average weight of all berries in a bunch - 183.0 g and average weight of all of all berries in a bunch - 183.0 g), the yield of the grapes was significantly higher than that of the Colombard variety (1,967 kg/stem).
The Ugni blanc variety was selected on the basis of the mechanical parameters of the cluster and berry (cluster weight - 282.4 g, average number of berries in a cluster - 166.8, average weight of all berries in a cluster - 183.0 g and average skin weight of 100 berries - 5.93 g).
The Ugni Blanc variety was characterized by a higher content of accumulated sugars, the Colombard variety by total acids, expressed as tartaric acid. Both varieties showed satisfactory varietal characteristics under the conditions of Fruška Gora and can be recommended for cultivation in this part of Serbia.

***Key words**: Colombard, Ugni Blanc, grape, berry, grape juice-must*

INTRODUCTION

The Srem wine-growing region is located on the slopes of Fruška Gora opposite the Danube (north) and the Sava (south) rivers. The area of the Srem wine-growing region excludes the peaks of Fruška Gora, which are part of the forest area of the national park. There is only one sub-region within the Srem region - Fruška Gora.

According to data from 2012, there are 2,141 hectares of vineyards in the Srem wine region, of which 1812.16 hectares are planted with grape varieties for wine production (Table 1). There are 2170 individual winegrowers, which accounts for 5.7% of agricultural activity in this region. The vineyards are located at an altitude of 90 to 270 meters, mainly on the northern and southern slopes (Przic and Markovic, 2019).

Table.1 Area under vineyards in Serbia and in Srem region

Total (ha)		Wine varieties (ha)	Table varieties (ha)
Serbia	22.149,97	17.482,72	4.667,25
Srem region	2.141,96	1.812,16	329.8
Percent	100	78.92	21.07

The Serbian wine-growing landscape is characterized by a long tradition of grape growing, with the Srem region being one of the most important wine-growing areas in the country. As the climate and market demand changes, the introduction of new grape varieties is crucial to maintain the country's competitiveness in the global wine market (Markovic, 2023).

Colombard, a white grape variety originally from the Charente region in France, is mainly used for the production of armagnac and white wines with crisp acidity.

Ugni Blanc, also known as Trebbiano in Italy, is mainly grown in regions known for large-scale viticulture due to its versatility in wine and brandy production.

Colombard is mainly grown in Gascony and throughout the southwest of France, including the Gers region. It budburst begins 2 days after the reference variety, Chasselas. The end of the ripening period, which occurs 3 weeks after that of Chasselas, is particularly late. This makes Colombard by ripen period on II epoh. Colombard is a fertile, very vigorous and high-yielding grape variety. It can be pruned long or short, depending on the type of wine to be produced. For still wines, short pruning is preferable in order to limit the yield and obtain richer grapes. The young leaves of the Colombard are yellow with bronze-colored spots. The adult leaves are spherical and kidney-shaped, either entire or three-lobed with a very open V-shaped petiole base, small teeth and no anthocyanin pigmentation of the veins. The berries of the Colombard variety are medium-sized, round to short oval and have a yellow-green color when ripe, which is characterized by their high acidity. The clusters are medium-sized, long conical to cylindrical, well-filled and often have a winged or double structure. They are supported by long stems, which contribute to the characteristic appearance of the variety (VIVC, 2024).

Ugni Blanc is cultivated over a large geographical area as it adapts well to a wide range of growing conditions. It is used for the production of still, dry wines, but is also the variety of choice for the production of Cognac and Armagnac.

Budburst it started 9 days after Chasselas, the reference grape varieties,

and fully ripens 3 to 4 weeks after it, making Ugni Blanc in a II epoh grape variety. To recognize Ugni Blanc, one should first look at its bunches, which are remarkably long, foxtail-shaped and occasionally fibrous at the tips.
The berries are round and their skin takes on a light pink colour when overripe. While the bunches are large, the berries themselves are small to medium-sized. The tips of the young shoots are densely covered with fine, flat-lying hairs, while the older shoots have indistinct or flattened nodes. The young leaves of the Ugni Blanc are bright yellow and turn into large, unevenly green, fully-grown leaves. The leaves are entire, with three or five lobes, and the petiole base is either slightly open or characterised by overlapping lobes. The leaf blade is serrated, wavy at the edges and has a blistered, waffle-like texture (VIVC,2024).

MATERIALS AND METHODS

The study was conducted in an experimental vineyard of the “Komuna” winery, located on the southern slopes of Fruška Gora mountain (GPS 45°5’45'' latitude and 19°82’35'' longitude). The vineyard was planted in 2014 and consists of a large number of wine and table varieties and clones.
The row spacing was 1.5 m and the distance between the plants was 0.9 m. The trellises were constructed from wooden poles and wire to allow optimal distribution of shoots, leaves and grapes in the space while ensuring good sun exposure. The training system was an “asymmetrical cordon” (Markovic and Przic, 2020) with a trunk height of 100 cm. A short pruning system with 3 spur buds was used.
For the study, 10 vines each of Colombard and Ugni Blanc were examined separately. The vegetative mass was determined by the mass of the pruned shoots on balance.
The mechanical composition of grapes and berries was determined according to the method of Marković and Pržić (2020). The weight, length and width of the bunches were measured, and the rachis (bunch stem) of each berry was carefully cut with scissors so that as little mesocarp as possible remained on stem. The number of berries per bunch was also determined, and the mass of berries per bunch and the mass of the stems were measured on an analytical balance. From each variety, 100 berries were selected for mechanical analysis, and after measuring the mass of the berries, berry skin and seeds were separated. The mass of seeds and skin of 100 berries was measured on an analytical balance, and the number of seeds in 100 berries was determined by counting. Other parameters were determined by calculation.
The sugar content in the grape juice (must) was determined using the Oeschle mostwage. The working principle of the Oeschle must scale is based on the determination of must density, which is measured in Oeschle degrees (°Oe).
The Oeschle degrees are the difference between the water density and the must density at 4ºC. The results of the sugar content are given as a percentage. The percentage of sugar was determined using the following formula:

$$\% \text{ of sugar} = {}^{\circ}Oe * 0.266 - 3$$

Total acid content was determined by the titration method using 0.1M NaOH. The working principle for determining the total acid content in grape must is based on the neutralization of all acids with NaOH

solution. Phenolphthalein was used as a color indicator.
The must was titrated with NaOH solution until the color changed from light red to dark green. Total acid content was then determined using the following formula:

Total acid (g/l) = used NaOH * F * 0.75

F – normality factor of NaOH solution

RESULTS AND DISCUSSIONS

Climat condition of microlocality

Grapevines are grown on different cklimate conditions, with numerous external factors directly affecting their growth and yield. The combined influence of environmental elements on vine characteristics is called vine ecology, which includes the climatic and soil (pedological) conditions of the region where the vines are grown.
In the Srem region, climate data was collected over a period of 30 years (1981-2010), providing a representative overview of the local climate.
The most important factors include temperature and precipitation, with the region being classified as having a temperate-continental climate.
Between 1981 and 2010, the average annual temperature was 11.4ºC, while the average temperature in the growing season reached 17.5ºC. The coldest month was January with an average minimum temperature of -3.6ºC, while July and August were the warmest with maximum temperatures of 27.8ºC and 27.9ºC respectively.
These temperature patterns indicate that the Srem region is very suitable for viticulture, as the coldest periods coincide with the dormancy of the vines, which increases resistance to low temperatures and minimizes the risk of frost.
The average annual precipitation was 620.3 mm, with June having the highest and February the lowest.
The high rainfall in June has a positive effect on the growth phase of the berries, as the grapes need a lot of water during this time. Conversely, lower rainfall in late summer and early autumn has a positive effect on the ripening of the grapes, especially for late-ripening varieties.
The location of Fruška Gora is generally favourable for viticulture in terms of climate and soil, especially due to its proximity to the Danube.

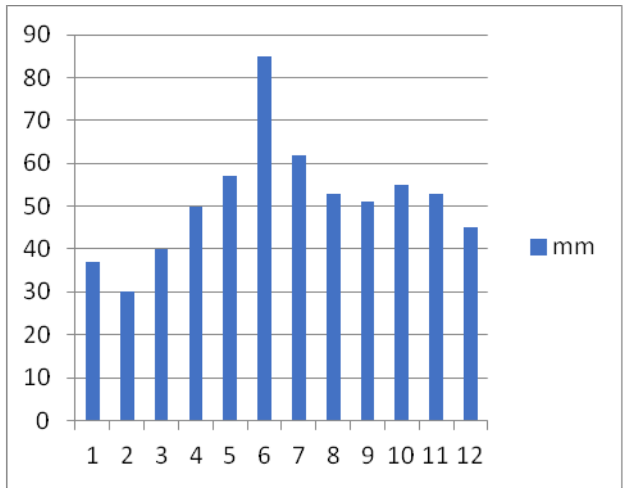

Figure 1. Average monthly precipitation for the period 1981-2010

Mechanical composition of cluster and berries

The average yield was higher for Ugni Blanc (2.3 kg/vine) than for Colombard varieties (1.97 kg/vine).
The mechanical composition of the bunches and berries was as follows: The Ugni Blanc variety had a greater average bunch mass (282.4 g), while the Colombard variety had an average bunch mass of (175.4 g);the average number of berries in a bunch was greater in the Colombard variety (134.4) and in the

Ugni Blanc variety (166.8); the average mass of berries in a bunch was greater in the Ugni Blanc variety (183 g), the average mass of skin in 100 berries was greater in the Ugni Blanc variety (5.93 g); the percentage of berries in clusters was the same for both varieties (95.6%); the percentage of mesocarp in berries was slightly higher for the Colombard variety (94.3%); the percentage of skin in berries was the same for both varieties (3.5%) and the percentage of seeds in berries was higher for the Ugni Blanc variety (2.76%) (Table 1). These results are in accordance with Markovic et al. (2017) and Zivkovic et al. (2021).

Table 1. Mechanical composition of cluster and berries

	Colombard	Ugni Blanc
Average cluster mass (g)	175.4	282.4
Average number of berries	134.4	166.8
Average berry mass (g)	140.3	183.5
Average skin mass in 100 berries (g)	4.94	5.93

The structure of bunches and berries is an essential characteristic of grape varieties. The berry skin plays a crucial role in this structure, as it contains phenolic compounds that pass into the wine and contribute to its aroma (Lataief et al., 2006). Structural indices and the percentage of berry skin provide important information to technologists during the maceration process in winemaking (Stoica et al., 2015).
Research by Zdunic et al. (2019), Zivkovic et al. (2016) and Downey et al. (2006) suggests that small berries with a higher berry skin to mesocarp ratio are preferable to varieties with medium to large berries. An increased pulp to skin ratio can lead to a dilution of tannins and anthocyanins in the juice.
During the alcoholic fermentation of the grape must, complex biochemical, physical and chemical processes take place that lead to the final wine. As Colombard and Ugni Blanc are varieties for the production of Cogniac and Armaniac, parameters such as sugar content, total acid content and pH of the grape must are considered very important.
The sugar content in the grape must was higher for the Ugni Blanc variety (72°Oe) than for the Colombard variety (67°Oe); total acid content was 4.28 g/l for the Ugni Blanc variety and 5.33 g/l for the Colombard variety; the pH was similar for both varieties (2.96 and 2.84).

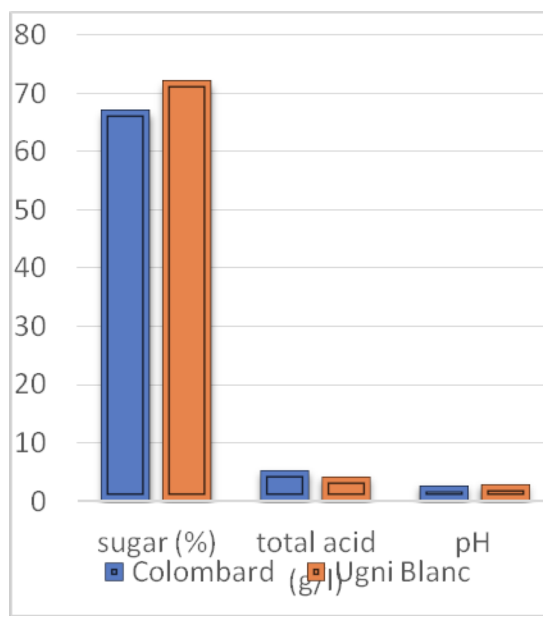

Figure 2. Chemical composition of grape must of varieties Colombard and Ugni Blanc

CONCLUSIONS

The following conclusions can be drawn from the analysis of the locality conditions and the agrobiological and technological characteristics of

Colombard and Ugni Blanc: Colombard grape juice has a higher sugar and total acid content compared to Ugni Blanc and is therefore suitable for producing well-structured, acidic wines with aging potential. The higher yield per vine makes Ugni Blanc an economically attractive option for winegrowers, especially those who want to produce lighter wines or brandies. Both varieties have proven to be highly adaptable to the climate and soil conditions of the Srem region, with appropriate vineyard management practices contributing to their successful cultivation. The results justify further expansion and testing of Colombard and Ugni Blanc in other wine-growing regions of Serbia, as they offer promising economic and oenological advantages.

In conclusion, the introduction of these varieties in the Srem region offers exciting opportunities for Serbian viticulture. Colombard and Ugni Blanc not only contribute to the diversity of grape varieties in the country, but also increase the potential for the production of high-quality wines suitable for both the national and international markets.

ACKNOWLEDGEMENTS

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AMPELOGRAPHIC CHARACTERISTICS OF THE LOCAL VARIETY BAGRINA GROWN IN THE CONDITION OF NEGOTINSKA KRAJINA WINE REGION

Jelena VIGNJEVIĆ, Nebojša MARKOVIĆ, Zoran PRŽIĆ

Faculty of Agriculture University of Belgrade, Nemanjina 6, Begrade, Serbia
Author email: vignjevicnegotin@gmail.com and zoranata4@yahoo.com

ABSTRACT

Bagrina is a local variety for the production of white wines. It is cultivated in the border area between Serbia and Romania, while it is rarely found in Bulgaria. The aim of the study were examination and comparison of the results obtained by mechanical composition of cluster and berries and the chemical characteristics of grape juice. The tests were carried out in the location of Rajac, Negotinska Krajina region, Serbia. The results of the three-year study showed that the mass of the bunch varied between 111 g and 218 g. The average number of berries was determined to be 97, while the average total weight of all berries in the bunch was 160.33 g. The number of berries varied in the individual test years as a result of the different degree of fertilization, taking into account that Bagrina has a hermaphrodite and functionally female flower type. The share of skin in the berry varied from 5.6% to 7.3%. The grape juice was found to contain 22.4% sugar and 3.64 g/l total acids. Based on the analyzed ampelographic characteristics and the increasing importance of the autochthonous and local assortment, the research results show that Bagrina has a significant oenological and economic potential under the conditions of the Negotinska Krajina wine region.

Key words: *Bagrina, Negotinska Krajina, grape, mechanical composition, grape juice*

INTRODUCTION

The Bagrina grape variety is known under several names, including Bragina, Bragina roşiu, Bagrina rara in Romania and Bagrina krajinska in Serbia. Originally from Romania, Bagrina was introduced to Serbia, where it is mainly grown in the Negotinska Krajina region. It is grown more frequently in Romania and less in Bulgaria. Ecologically and geographically, the Bagrina belongs to the *Proles pontica* group (Przic and Markovic, 2019).

The Bagrina vine varieties is characterized by a vigorous trunk and young shoots with a hairy texture and purple-colored unopened leaves. The mature shoots are thick, reddish-brown with purple nodes. The leaves are medium-sized, three-lobed, with reddish veins and a pronounced petiole. The flowers are morphologically hermaphrodite but functionally female, with five curved anthers that produce sterile pollen, resulting in irregular fertilization and often loose bunches. The berries are medium-sized, round or slightly flattened and have a thick, pale pink skin that is thin. Airless, unfertilized berries are usually smaller and ripen earlier than the normal berries. The clusters are medium to large, moderately compressed and typically loose, with stems that can be greenish or reddish (Žunić and Garić, 2017).

The Bagrina grapevine has a late ripening period, typically in the third epoch. Pollination is irregular, but good pollinators include Prokupac, Smederevka and Plovdina. The fertility coefficient is between 1.3 and 1.5, and yields vary between 3 and 18 tons per hectare. Pruning can be short (spur with 2 buds) or mixed (arc with 8 buds). Suitable cultivation forms are those that allow both short and mixed pruning. For optimum growth, Bagrina thrives in loose, well-drained, moderately fertile and sandy soils. It has a frost tolerance of -16 to -18°C and has variable resistance to the most important diseases: sensitive to Plasmopara viticola, medium resistance to Uncinula necator and resistant to Botrytis cinerea. It combines well with rootstocks such as Berlandieri x Riparia, Kober 5BB, Teleki 8B, SO4 and Teleki 5C. The must contains 18-23% sugar and 5-8 g/l total acids (Žunić and Garić, 2010). Serbia's wine-growing zoning identifies three key areas: Central Serbia, Vojvodina, and Kosovo and Metohija. These areas encompass 22 regions and 77 sub-regions, along with smaller winegrowing oases, contributing to a rich variety of Serbian wines (Avramov and Zunic, 2001). The Negotinska Krajina region belongs to the area of Central Serbia, which includes four sub-regions: Ključko, Brzopalanačko, Mihajlovačko and Negotinsko. The average altitude of this region is between 60 and 480 m, and the vineyards are located at 100-270 m. Whole region is surrounded by the Carpathian Mountains and the Danube river. The altitude level gradually decreases from west to east and ends at the Danube river. There are 2,429 producers with vineyards in the Negotinska Krajina region. Of the total cultivated area of 550 hectares, the largest part (489 hectares) is planted with vines (Table 1).

Table 1. Area under vineyards in Serbia and in Negotinska Krajina region

	Total (ha)	Wine varieties (ha)	Table varieties (ha)
Serbia	22.149,97	17.482,72	4.667,25
Negotinska Krajina region	550,67	489,16	61,51
%	100	78.92	21.07

MATERIALS AND METHODS

The research were carried out in the village of Rajac (GPS 44° 09´ 37'' and 22° 56´ 08'') in a vineyard planted in 2014. Spacing between the rows is 1 m and between the vines 1 m. The Krajinski training system with short pruning was used.

For this study, 10 vines from the Rajac locality in the Negotinska Krajina region, Serbia, were examined separately for three consecutive years (2018-2020).

The mechanical composition of grapes and berries was determined according to the method of Marković and Pržić (2020).

The weight, length and width of each bunch were measured, and the bunch stem of each berry was carefully removed with scissors, taking care to leave as little mesocarp as possible on the bunch stem as possible. The number of berries per cluster was also recorded, and the mass of the berries and the mass of the stems were measured using an analytical balance.

A total of 10 clusters were randomly selected for the experiment. Various measurements were taken in a controlled laboratory environment, including the mass of the cluster, the number of berries in the cluster, the mass of all berries in the cluster and the length and width of the cluster. The weight of each berry was also determined.

A random sample of 100 berries was taken for the berry analysis.

The seeds, the skin and the mesocarp were separated mechanically using a jute cloth. The berry skin and seeds were air-dried and their weight was measured. The number and weight of the seeds were also recorded. In addition, the mechanical composition of the berries was determined by measuring the mass of 100 berries, the mass of the skin of 100 berries, the mass of the seeds of 100 berries and the mass of 100 seeds.

The sugar content of the grape must was determined by the Oechsle mostwage (°Oe) and the total acidity by the titration method using 0.1M NaOH.

The working principle of the Oechsle mostwage is based on the determination of must density, which is measured in Oechsle degrees (°Oe). Degrees Oechsle degrees represent the difference between the water density and the must density at 4°C. The results of the sugar content are usually given as a percentage.

The following formula is used to determine the sugar content:

$$\% \text{ of sugar} = (°Oe * 0.266) – 3$$

The total acid content was determined by a titration method using 0.1 NaOH. The working principle for determining the total acid content in grape must is based on the neutralisation of all acids with NaOH solution. Phenolphthalein was used as a colour indicator. The must was titrated with NaOH solution until the colour changed from light red to dark green. The total acidity was then determined using the following formula:

$$\text{Total acidity (g/l)} = \text{NaOH used} * F * 0.75$$

F - normality factor of the NaOH solution

The glicoacidometric index was determined as the ratio between the sugar content and the total acid content.

RESULTS AND DISCUSSIONS

Climate and soil conditions

The ecology of the grapevine encompasses the combined effects of external factors on the growth and productivity of the vine. It includes the study of the specific climatic and soil conditions of the area in which the vine is grown. These environmental factors directly affect various aspects of grapevine development and yield. The climate, including temperature, rainfall, solar radiation, humidity and wind conditions, has a significant influence on the vine's life cycle (Markovic, 2023)..

The average temperature during the growing season varies between 17.4 and 18°C. The cool night index is between 11.5 and 13.5 and is an important indicator that the conditions are favorable for the grapes to ripen in September, which is important for the formation of sufficient amounts of coloring and aromatic substances in the grapes.

In summary, the climatic conditions for growing Bagrina in this region are favorable and this is the reason why it is known and significant in Serbia.

A cold wind comes over the Homolje Mountains and brings rainfall.

The lowest frequency of wind direction is southerly (25.92%) and the highest is the western (192.08%). The lowest mean annual wind force is south wind (1.34 m/s) and the highest is west wind (3.25 m/s).

Vertisol, eutric Cambisol and desert soils are present in most of the vineyards in this wine-growing region.

The mechanical analysis of the soil, carried out from the soil surface to a depth of 30 cm and from 30 cm to a depth of 60 cm, showed that the fraction of total sand increases with depth,from 33.9% to 37%, while the content of loam and clay decreases from 66.1% to 63.%.

The chemical analysis showed that the phosphorus, potassium and nitrogen content as well as the pH value were optimum.

Mechanical composition of cluster and berries

The berry skin is an important structural element as it contains phenolic compounds that are extracted from the wine and give it colour and aroma (Zdunic et al., 2019; Zivkovic et al., 2019; Blackford et al., 2021).

The analysis of the mechanical composition of the bunch, as part of this research, was carried out on a representative sample of optimally ripe grapes.
The weight of the clusters was determined individually on precise analytical balance in the laboratory of the Faculty of Agriculture in Belgrade.
During the three-year study, it was found that the average bunch weight (g) of the Bagrina variety varies between 111 and 218 g.
Then all the berries were removed individually from each bunch, and after counting the berries, the number of berries was determined from a minimum of 49 to a maximum of 150.
After the berries had been removed from the bunch, the mass of the berries was measured on an analytical balance.
The average mass of berries per bunch was determined by subtracting the mass of the skin from the total mass of the bunch. The mass of berries in a bunch varied between 113 g and 208 g.
The mechanical composition of the berries was analyzed on a sample of 100 berries. During further processing of the sample, the skin and seeds were removed from each berry, the skin was washed so that no more pulp adhered to it and then dried on absorbent paper so that no more water adhered to the skin.
The seeds were also washed and dried on absorbent paper.
The weight of the skin and seeds was then measured on a precise analytical balance.
On the basis of the measured and calculated masses of berries, skin, seeds, their ratio, i.e. their proportion of the bunch, was determined.
Of the total weight of the bunch, 5.22% is accounted for by the skin and 94.77% by the berries, 4.38% by the seeds and 5.92% by the skin.

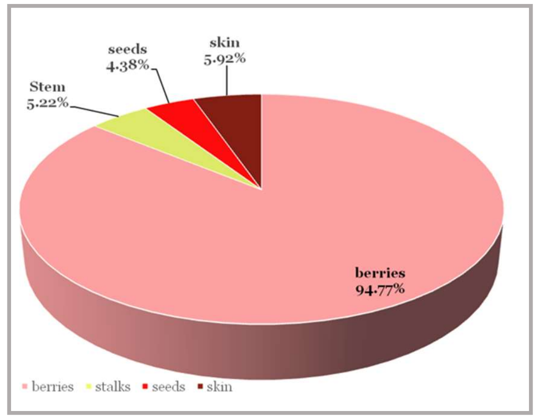

Figure 1. Proportion of different parts of the cluster

The average share of the mesocarp in the berry in this research is 86.92%, while the seeds participate with 5.56% and the skin with 7.52%.

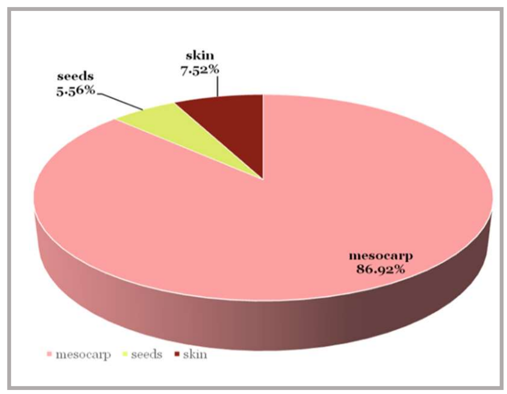

Figure 2. Proportion of different parts of grape berry

The variability of the investigated parameters is a direct consequence of the different degree of fertilization, considering that Bagrina has a morphologically hermaphrodite but functionally female flower type. For this reason, pollinator varieties such as Muscat Ottonel, Začinak, Prokupac, Tamjanika Bela, Game, Pinot noir are used, and in the vineyard where the experiment was conducted, the pollinator variety is Plovdina.
The sugar content of the experimental grapes isolated from grapes of the Bagrina

variety was in a narrow range from 22.0% to 22.8%.

Based on the sugar content, the value for the potential theoretical alcohol content in the wine (% vol.) was recalculated, with the experimental wine made from grapes from 2018 having the lowest content (12.98 % vol.), while the highest theoretical alcohol content was expected for wines made from grapes from 2020 (13.45 % vol.).

The total acidity (g/l) ranged from 3.64 g/l to 5.52 g/l. The determined average acid content is lower compared to previous Serbian studies in the Niš wine-growing region (7.03 g/l for grape juice from vineyards with traditional cultivation methods).

The glycoacidometric index ranged from 5.87 to 6.48.

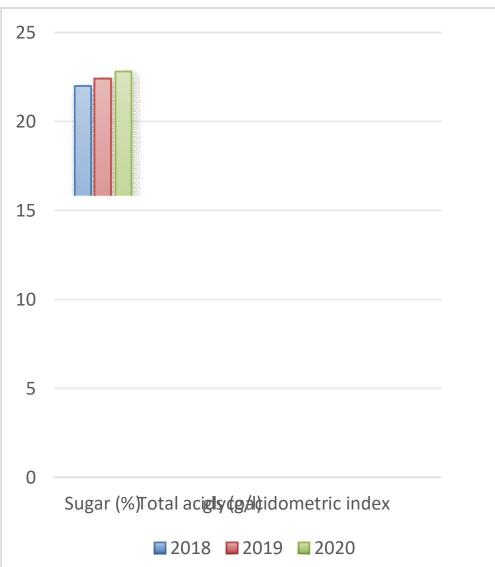

Figure 3. Chemical composition of Bagrina must

CONCLUSIONS

Considering the ecological and agrobiological factors, the results of the three-year study lead to the following conclusions:

- The mass of the bunch varied between 111 g and 218 g.
- The average number of berries was determined to be 97, while the average total weight of all berries in the bunch was 160.33 g.
- The number of berries varied in the individual test years as a result of the different degree of fertilization, taking into account that Bagrina has a hermaphrodite and functionally female flower type.
- The proportion of skin in the berry varied between 5.6% and 7.3%.
- The grape juice contained 22.4% sugar and 3.64 g/l total acids.
- From the analyzed ampelographic characteristics and the increasing importance of the autochthonous and local assortment, it can be concluded that Bagrina has significant oenological and economic potential under the conditions of the Negotinska Krajina wine region.
- Bagrina is used to produce light, aromatic wines that typically have a fine balance between acidity and sweetness. The white wines produced from the Bagrina variety are characterized by a higher content of actual and total alcohol as well as a certain content of reducing sugars, so that they can be classified as dry, semi-dry and semi-sweet wines.
- Efforts to preserve and promote Bagrina contribute to the diversity and richness of the global wine landscape.

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EDAMAME SOYBEAN YIELD UNDER DIFFERENT NUTRIENT AND WEED MANAGEMENT

Natalija PAVLOVIĆ[1*], Željko DOLIJANOVIĆ[2], Milena SIMIĆ[1] and Milan BRANKOV[1]

[1] *Maize Research Institute "Zemun Polje", Slobodana Bajića 1, 11185 Belgrade, Serbia;*

[2] *University of Belgrade - Faculty of Agriculture, Nemanjina 6, 11080 Belgrade, Serbia;*

**Correspondence: npavlovic@mrizp.rs*

ABSTRACT

Edamame is a vegetable soybean type harvested at the R6 development stage, when immature green beans are used in the human diet. It is recognised as a highly nutritious and healthy food, commonly eaten in the form of a salad or snack. Appropriate nutrient supply and weed control are prerequisites for successful production, so the aim of this study was to examine the impact of different fertilization systems as well as herbicide treatments on the pod yield of edamame soybean. The experiment was conducted during the 2022 growing season when two edamame varieties Chiba green and Midori giant, were sown. Applied treatments were: F1: mineral fertilizers (NPK + Urea); F2: mineral + microbiological fertilizers (two Bradyrhizobium japonicum strains); and F3: mineral + microbiological + foliar fertilizers (based on N, K_2O, Zn, Cu, B, Mo); H1: PRE-EM herbicides (s-metolachlor + metribuzin); H2: PRE-EM + POST-EM herbicides (imazamox + cycloxydim); H3: control. The tested parameter was pod yield in t ha^{-1}. Pod yield varied on average between 7.34 and 17.95 t/ha. Differences between pod yields were statistically under the influence of cultivar x herbicide x fertilization. It seems like the best effect on yield was achieved by combining the application of mineral microbiological and foliar fertilization with full herbicide protection.

Key words: cultural practices, fertilization, soybean, yield

INTRODUCTION

Edamame (vegetable soybean) is a popular healthy food used in human nutrition worldwide. The centre of origin is China, which is also the main producer and exporter of frozen edamame (Li et al. 2013). Vegetable soybean (or edamame) account for approximately 2% of world soybean production (Dar et al., 2023). Edamame is utilized as a vegetable in the human diet in the form of a snack or salad, opposite to standard soybean which is important animal feed and raw material for numerous industries. It is sold fresh or frozen, within pods or without them and only beans are edible. Unlike standard soybean which is harvested at the R8 development stage, the right time for edamame harvesting is at the R6-R7 stage, while pods and beans are still green just before they turn yellow (Zeipina, 2017). Edamame has a shorter vegetation period, and it is determinant according to growth type. Plants are shorter than standard soybean, but they develop more branches than standard ones (Zeipina, 2022). Seeds of edamame are larger than those of standard soybean, so the sowing density is lower (Zeipina, 2017). Compared to standard soybean, edamame contains higher level of vitamins A, C, K and B (Takahashi and Ohyama. 2011), Fe (Sikka et al. 1978), asparagine, alanine and glutamic acid (Yanagisawa et al. 1997), starch, total sugar content, sucrose, glucose and fructose (Tsou and Hong. 1991). The lipid content (Carson et al. 2011), trypsin inhibitor content, cysteine and methionine in proteins (Nair et al. 2023) as well as raffinose, stachyose and crude fiber level are (Tsou and Hong. 1991) lower.

Application of complete fertilizers (NPK) is the principal and irreplaceable component of plant nutrition in conventional agriculture systems. It returns a lack of N, P, and K carried out with the yield. As a legume, soybean is a well-known nitrogen-fixing plant that converts atmospheric nitrogen into ammonia (N form available to plants). It is possible due to symbiosis with bacteria, which form nodules on soybean roots. This symbiosis should be supported by using microbiological fertilizers (consisting of *Rhizobium* bacteria) which can accelerate nodule formation and increase yield potential (Wayan et al., 2022). Deficiency of micronutrients such as B, Cu, Mg, Mn and Zn, is commonly present in the soil (Kannan, 2010). Micronutrients are important for optimal plant growth and development, so more attention must be given to compensating for their deficiencies. Foliar application of micronutrients is suitable practice for adding nutrients in low quantities (Patil and Chetan, 2018). Plant reactions to foliar application are faster than to soil application (Dragičević et al., 2016). Biofertilizers and foliar fertilizers can supplement, but not replace complete fertilizers.

Edamame is a weak competitor against weeds, especially in the early stages of development (Prachand et al., 2015) before the rows close. Despite the harmful effects that herbicides have on the environment and many other alternatives available for weed suppression, they are still the most effective solution. Herbicides, applied before soybean emergence, are successful in controlling broadleaves and narrow leaf weeds. Foliar application of post-emergence herbicides for broad-leaf weeds has to be applied up to the first three trifoliate leaves development, because after that, soybean becomes sensitive.

The aim of this study was to examine the impact of different fertilizers (NPK, foliar and biofertilizer) as well as herbicide treatments (post- and pre-emergence) on the pod yield of edamame soybean.

MATERIALS AND METHODS

The experiment was conducted during the 2022 growing season at the experimental field of the Maize Research Institute "Zemun Polje" in a split plot design in four replications. Two edamame cultivars, Chiba green (C1) and Midori giant (C2), imported from the USA from organic production, were sown. Sowing was conducted at the beginning of the 3rd decade of April, with an arrangement of 50 cm inter-row space and 7.5 cm intra-row space (266,000 plants ha^{-1}). The size of the elementary plot was 20 m^2. The following fertilizers and herbicides were applied in the experiment: F1: mineral fertilizers; F2: mineral + biofertilizer; F3: mineral + biofertilizer + foliar fertilizer; H1: pre-emergence (PRE-EM) herbicides; H2: PRE-EM + post-emergence herbicides (POST-EM); H3: control – without herbicides. For mineral fertilization, NPK fertilizer (6:24:12) in the amount of 250 kg ha^{-1} was applied in the autumn, and 270 kg ha^{-1} of urea (46% N) was applied in the spring prior to edamame sowing. Seeds were inoculated with biofertilizer (which contains two *Bradyrhizobium japonicum* strains in abundance of 10^8 ml^{-1}) just before sowing. For foliar fertilization with micronutrients, Fitofert Speed-s fertilizer (based on: N 5%, K2O 2%, C 4%, Zn EDTA 0.3%, Mn EDTA 1%, Cu 0,3%, B 0,5% Mo 0,5% - 3 l ha-1) was used in an amount of 3 l ha^{-1} when the soybean developed 2nd to 3rd trifoliate leaf. Applied pre-emergence herbicides were Dual Gold (a.i. s-metolachlor) in the amount of 1.4 l ha^{-1} and Lord (a.i. metribuzin) in the amount of 0.5 kg ha^{-1}. They were used after sowing before emergence. Post-emergence herbicide Pulsar (a.i. imazamox) in an amount of 1.1 l ha^{-1} was applied together with foliar fertilizer, while Focus Ultra (a.i. cycloxydim) in an amount of 2 l ha^{-1} was applied 10 days later. Pod yield was determined at the R6 development stage (end of June and the middle of August) from the two central rows of each elementary plot. Data were processed by one-way factorial analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Pod yield ranged from 7.34 to 17.95 t ha^{-1}. The lowest yield was recorded in the Chiba green (C1) cultivar under H3F1 treatment, while the highest yield reached Midori giant (C2) under H2F3. The C2 cultivar exceeded C1 in pod yield, 5 to 66% approximately, which was especially notable under H3 treatment, where the yield was more than 50% higher through all F treatments. The interaction of the cultivar, fertilization system, and herbicide treatment had a significant impact on edamame pod yield (Table 1). A significant difference in pod yield between two cultivars was evident under H1 treatment only in F1, where the C1 cultivar produced 3.67 t ha^{-1} less yield than C2. For C1, no yield difference was observed between F2 and F3 treatments, while under F1, the yield was significantly lower. For C2, there was no significant difference across fertilization treatments, neither under H1 nor for H2 treatment. However, under H2, the C2 cultivar had 4.51 t ha^{-1} higher pod yield on average compared with C1. Within each cultivar, under H2 treatment, no significant variations were found among fertilization systems. In control plots (H3), where herbicides were not applied, differences among F treatments were statistically significant within the cultivars. Cultivar C1 had significantly lower yield under H3 treatment (8.74 t ha^{-1} in average) in comparison to H2 and H1 (11.86 t ha^{-1} and 12.13 t ha^{-1} in average, respectively) apart from H1F1 (9.96 t ha^{-1}). Regarding C2, pod yield under H3, for F2 and F3 was higher than those of H1, while under F1 yield was the lowest (11.59 t ha^{-1}).

Table 1. Interaction effects of the cultivar (C), fertilization system (F), and herbicide treatment (H) on pod yield (PY) of edamame soybean (t ha^{-1}).

C x F x H		C1	C2
H1	F1	9.96 c	13.63 ef
	F2	12.40 de	13.81 ef
	F3	13.22 e	13.87 ef
H2	F1	11.96 d	16.17 gh
	F2	12.04 de	15.81 gh
	F3	12.39 de	17.95 h
H3	F1	7.34 a	11.59 d
	F2	8.77 b	14.54 f
	F3	10.12 c	15.65 g

C1 – Chiba green; C2 – Midori giant; H1 – PRE-EM herbicides; H2 – PRE-EM + POST-EM herbicides; H3 – control; F1 - mineral fertilizers; F2 - mineral + biofertilizer; F3 - mineral + biofertilizer + foliar fertilizer;

Different letters indicate significant differences according to LSD test at $p < 0.05$.

It can be observed from Table 1 that the impact of fertilization treatments is not as clear within a single herbicide treatment, while comparing different herbicide treatments makes this influence more evident, except for H3 treatment, where the differences among fertilization systems are pretty obvious. However, although not always statistically significant, a gradual increase in pod yield can be observed moving from F1 to F3 in both cultivars. That can be a result of the combined effect of both mineral and microbiological fertilizers, as well as the nutrient management, which includes the application of mineral, microbiological and fertilizer with microelements. Maruthi and Paramesh (2016) reported that combined application of NPK fertilizers, organic fertilizers, and biofertilizers improved emergence and seed quality parameters of edamame. Uniform emergence is a prerequisite for good crop establishment, which, in synergy with other optimal agroecological conditions, affects crop productivity. de Oliveira et al. (2019) and Moloi and Khoza (2022) examined the impact of fertilizers with micronutrients on morphological and productive traits of edamame and didn’t find significant influence on tested parameters. Chiba green decreased in pod yield under H3 treatment, which was expected due to high weed pressure, but Midori giant had a higher yield under H3F3 than under H1F3, which was unexpected due to the fact that pre-emergence herbicides should suppress weeds at the beginning of the growing season when soybean is especially sensitive. Some of the explanations for this could lay in insufficient pre-emergence herbicide efficacy, uneven distribution of weed seeds across the plot where the crop is sown, as well as competition between soybean and weeds for light, when the soybean plant elongates its stem, forming more nodes and consequently, producing more pods. Pornprom et al. (2010) consider that it is possible to avoid post-emergence herbicides if pre-emergence herbicides effectively manage weeds. Crawford and Williams (2018) concluded that edamame developed from larger seeds is a better competitor to *Abutilon theopharsti* 2–8 weeks after emergence in comparison to plants developed from smaller ones. A higher yield of Midori giant is expected because it has about 10 days longer period of vegetation.

CONCLUSIONS

Both cultivars had the lowest pod yield on the control plots with no applied herbicides, where only mineral fertilizers were applied (H3F1) and the highest one with combined application of mineral, foliar and microbiological fertilizers together with full herbicide protection with pre- and post-emergence herbicides. It is obvious that Midori giant cultivar is more productive than Chiba green. To obtain more reliable and conclusive results, edamame needs to be cultivated for several years.

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