PROCEEDINGS OF
5TH INTERNATIONAL SYMPOSIUM
ON BROOMRAPE IN SUNFLOWER

1-3 NOVEMBER, 2023

ANTALYA, TURKEY

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Organized by
Trakya University
International Sunflower Association
International Researchers Association

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WELCOME NOTES

The parasitic angiosperm broomrape (*Orobanche cumana* Wallr) causes economic damage in sunflower production in a number of countries around the world, but especially in Central and Eastern Europe, Spain, Turkey, Israel, Iran, Kazakhstan, and China. For almost a century, there has been a constant tug-of-war between sunflower breeders and *Orobanche cumana*, with frequent changes in which side has the upper hand. Almost as soon as the breeders find a source of resistance to the latest race of the pathogen, broomrape responds by evolving into another virulent race. The development of resistant cultivars as well as optimized managing strategies is a high priority in controlling this parasite, over the world.

This is the 5th specific symposium on broomrape in sunflower, after those held in Turkey in 2008, Moldova in 2011, Spain in 2014 and Romania, in 2018.

The symposium is organized by Trakya University and International Researchers Association in cooperation with the International Sunflower Association (ISA). The symposium will be held in Megasaray Westbeach Hotel, Antalya, Turkey, on November 1-3, 2023. The symposium covers all aspects related to broomrape parasitisms in sunflower, including parasite biology, physiology, parasite-host interaction, the racial status of broomrape, genetic resistance, molecular breeding, chemical control using herbicide-tolerant, and integrated management.

The symposium gathered sunflower scientists from around the world, and present their recent achievements. The organizers also invited relevant stakeholders to provide a view on the broomrape situation around the world as well as prospects to overcome the limitation for sunflower production, imposed by this parasitic weed.

There are 18 oral presentations and 8 poster presentations. There will be 146 participants from 18 countries from the world.

We would like to thank all of you for joining this conference and we would like to give also special thanks to our sponsors and collaborators for giving us a big support to organize this event.

Prof Dr Yalcin KAYA
Head of the Organizing Committee

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INVITED SPEAKERS

Dr Leonardo VELASCO	Broomprae resistance from wild species
Dr. Dragana MILADINOVIĆ	Broomprae resistance utilizing genomic tools
Dr Mehmet DEMIRCI	CLEARFIELD control Broomrape and weeds.

EDITOR OF THE PROCEEDINGS ABSTRACT BOOK

Prof Dr Yalcin KAYA, Assoc Prof Dr Necmi BESER

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10^{30} - 11^{10}	**Dr Leonardo VELASCO, Institute for Sustainable Agriculture CSIC, Spain "**Broomrape resistance from wild species"
11^{10} – 11^{50}	**Prof Dr Dragana MILADINOVIĆ - Novisad Research Inst, Serbia** "New approaches for achieving durable resistance to broomrape in sunflower"
11^{50} - 12^{30}	**Dr Mehmet DEMIRCI, Freelancer, Turkey - "**CLEARFIELD control of broomrape parasite & weeds: A success story in sunflower"
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4 15^{20} - 15^{40}	Determination of resistance of oil sunflower maintainer lines to broomrape populations in the Çukurova region – Ayse Nuran Cil, Yılmaz Yaşar, Abdullah Çil
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KRASELA"- THE FIRST BULGARIAN SUNFLOWER HYBRID, RESISTANT TO BROOMRAPE (RASE H) AND STABLE YIELD POTENTIAL UNDER LIMITED MOISTURE CONDITIONS

Nina Nenova
Department of Sunflower Breeding Dobrudzha Agricultural Institute, General Toshevo, Bulgaria
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ABSTRACT

Plant responses to stress are an increasingly frequent subject of research investigations, especially if the stress factors are biotic and abiotic. The parasite broomrape can reduce sunflower yields to zero levels, and as climate change intensifies, droughts are getting longer, affecting agriculture and human livelihoods. In the breeding programs of DZI – General Toshevo main objective is to create drought-resistant and disease-resistant hybrids sunflower. The aim of this study is to make a complete characterization of the conventional sunflower hybrid "Krasella" and its reaction to the resistance of the parasite Orobanche cumana Wallr. (race H) in a particularly dry and middle wet year. Ecological experiments there are in different regions of Bulgaria /four points - Gen. Toshevo, Brashlen, Radnevo and Selanovtsi/ and Ukraine /2 points - Zaporozhye and Kirovograd/. The indicators "seed yield", "oil yield" compared to the relevant standard during the years of testing and the resistance of the hybrid to diseases - mildew, fhoma, fhomopsis, and the parasite Orobanche cumana are observed and traced. Over the years of the study, hybrid Krasela has shown stable yields, even in the particularly dry year – 2020 and the middle wet 2019 years.

Key words: sunflower, biotic and abiotic stress factors, *Orobanche cumana* Wallr.

DETERMINATION OF AGRICULTURAL POLICY FACTORS AND THEIR EFFECTS AFFECTING PRODUCERS' PREFERENCE FOR PRODUCTION OF OILY SUNFLOWER: THE CASE OF THRACE REGION

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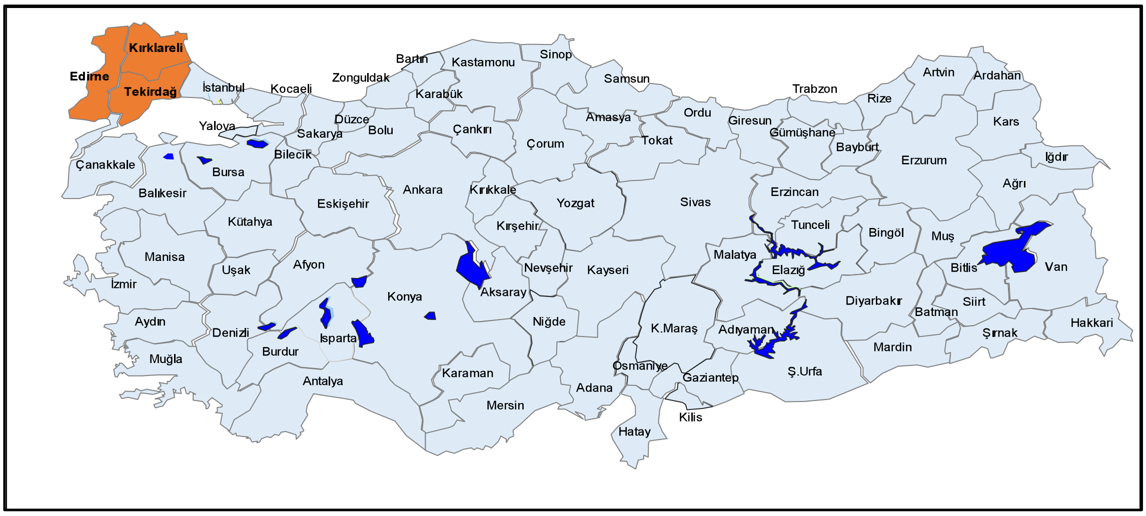
ABSTRACT

In this study, it is aimed to analyze the factors affecting the production preferences of producers of oily sunflower. It covers the provinces of Tekirdağ, Edirne and Kırklareli in the Thrace Region, which is determined as a research area, and stands out especially with sunflower production in our country. The Thrace Region refers to the geographical area where sunflower production is carried out to a large extent in our country with its sunflower cultivation area of 3.1 million. According to the results obtained in the study conducted based on micro data, the availability of the land and the suitability of the production activity and the level of profitability were determined as effective factors in the sunflower production decision of the producers. However, in the selection of sunflower seeds, price and sales channel criteria were determined as determining priority variables. In the study, the problems related to sunflower production activity are raised as high input costs and marketing issues in order of priority. In addition, increasing the supports directed to sunflower production emerges as a producer expectation in the region.

KEYWORDS: Sunflower, Thrace Region, Production, Producer Behavior

1. INTRODUCTION

Our research area covers the whole of the Thrace Region, especially Tekirdağ, Edirne and Kırklareli provinces. This region, which is located in the most North West region of our country, is one of the important regions of our country in terms of plant production.
It is possible to come across very different morphological units in our Thrace Region, which is located in the southeastern part of the Balkan peninsula. To list the mainly, it is possible to observe mountains and hills with different elevations, as well as plateaus with less elevation and different large and small plains.



Source: Anonymous 2019.

Map 1. Location and location of the Thrace Region in Turkey

2. LITERATURE REVIEW

2.1. Investigation of Sunflower Plantations in the Thrace Region

When the sunflower cultivation areas of Tekirdağ, one of the provinces of our Thrace Region, are examined as the last three years, it is possible to see a wavy cultivation area. In 2018, a total of 1,481,286 sunflowers were planted, while in 2019, this area decreased to 1,365,350. When it comes to 2020, our last evaluation year, we can see that the cultivation area has reached 1,424,669, approaching 2018. In our province of Tekirdağ, where producer preference varies according to different factors, the spread of canola production, especially in competition with sunflower, in some years causes fluctuations in the cultivation areas.

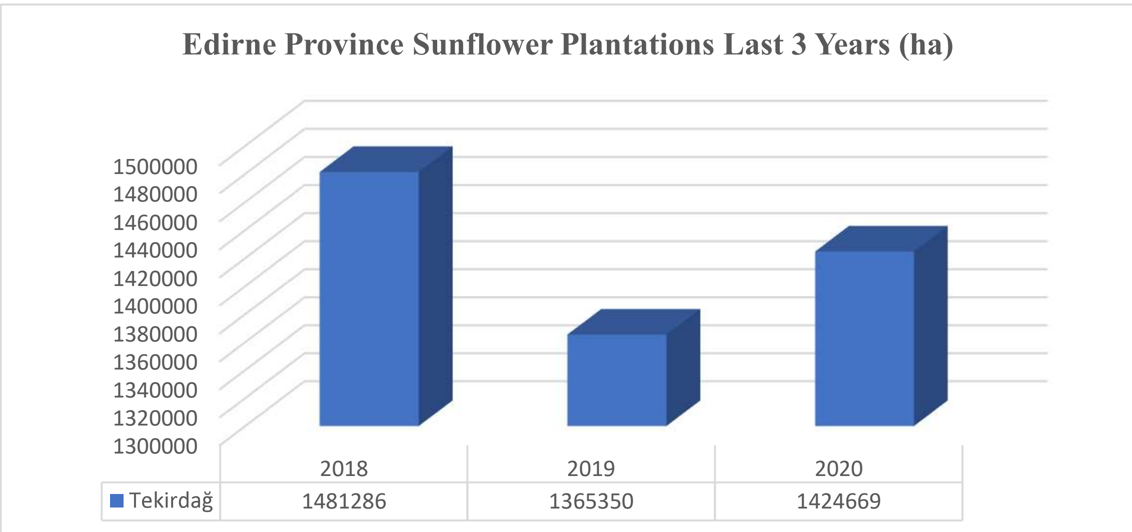


Figure 1. Tekirdağ Province Sunflower Plantations Last 3 Years (ha) (Source: TurkStat, 2020)

When our Edirne Region, which is another province of our Thrace Region, is examined, we see that while similar cultivation areas were formed in 2018 and 2019, this area decreased in 2020. The sunflower species, which reached 954,512 cultivation areas in 2018, almost protected its area in 2019 and had 950,498 cultivation areas. When we look at 2020, our last review year, it is possible to say that there is a cultivation area that has declined to 909,155. Here, we can say that the fact that the grain group in particular is more intensively cultivated in the region is a big factor.

Figure 2. Edirne Province Sunflower Plantations Last 3 Years (ha)(Source: TurkStat, 2020)

When we look at our province of Kırklareli, which is one of the important provinces of our Thrace Region, we can say that although it has a parallel cultivation area in 2018 and 2019, there is a significant increase in 2020. Our province, which had a total sunflower planting area of 750,021 in 2018, had 740,511 sunflower planting area in 2019. In 2020, with the increase, it is seen that 778,064 sunflower planting areas are realized in this province.

If the sunflower cultivation areas of our Thrace Region in general are examined, we can say that the highest planting area was realized in 2018. The Thrace Region, which has a sunflower cultivation area of 3,185,809, has not been able to reach this figure again in the last three years. The Thrace Region, which created a sunflower planting area of 3,056,359 with a serious decrease in 2019, reached 3,111,888 sunflower planting area in 2020. These fluctuations in the sunflower planting area can be interpreted as the different gains that alternative species to sunflower cultivation provide to the producers.

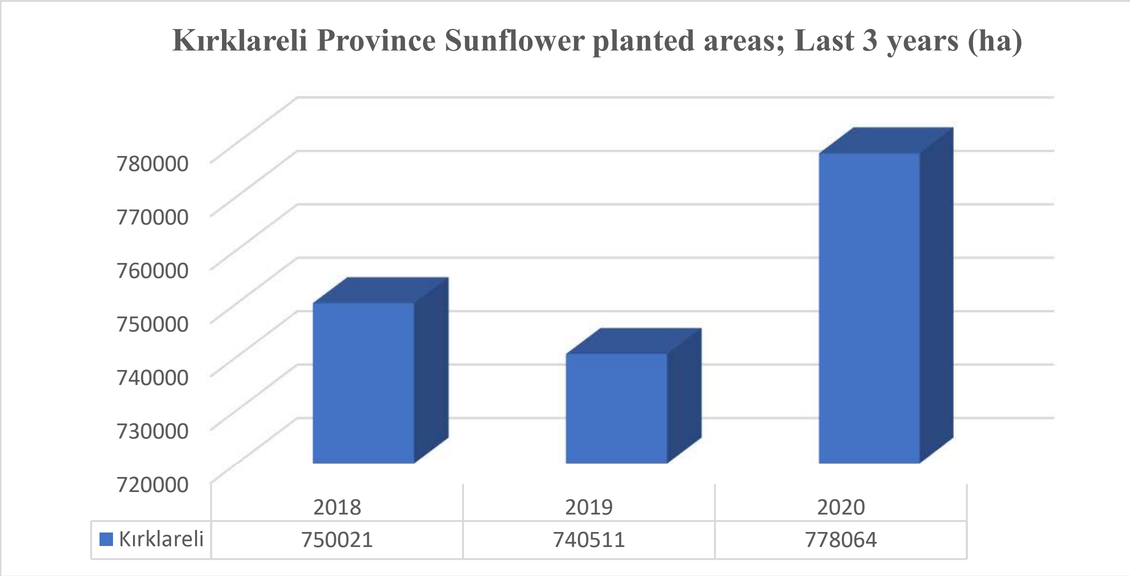


Figure 3. Kırklareli Province Sunflower Plantations Last 3 Years (ha) (Source: TurkStat, 2020)

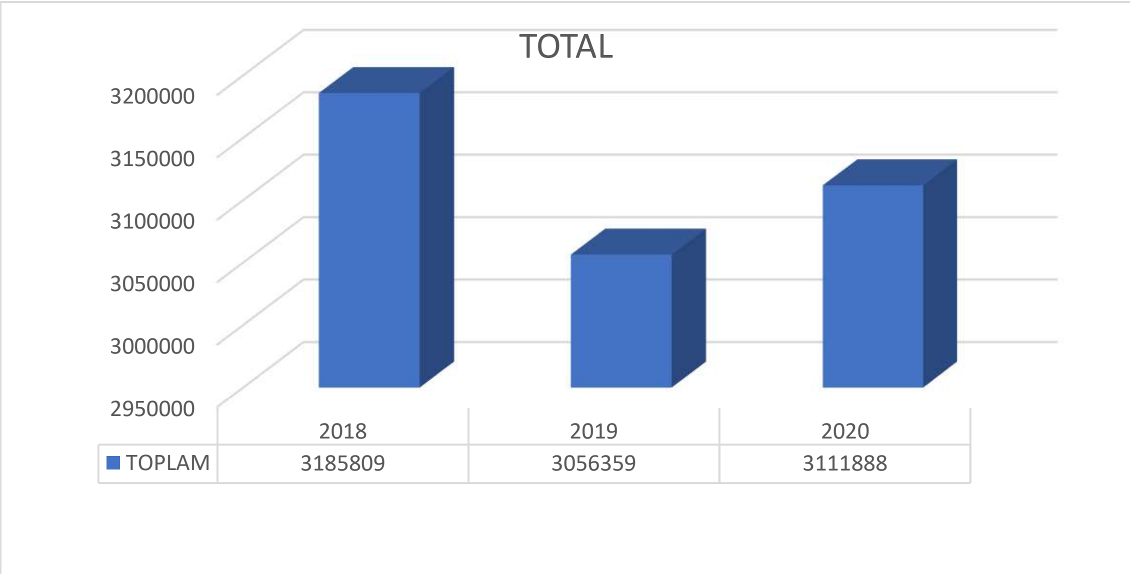


Figure 4. Thrace Region Sunflower Plantations Last 3 Years (ha) (Source: TurkStat, 2020)

2.2. Investigation of Sunflower Production Amounts in the Thrace Region

When we examine the sunflower production amounts of the Thrace Region in the last three years, it is possible to see an increasing graph. Sunflower, which saw a production figure of 777,807 tons in 2018, has reached 802,798 tons in 2019 and 820,836 tons in 2020 with an increasing graph.

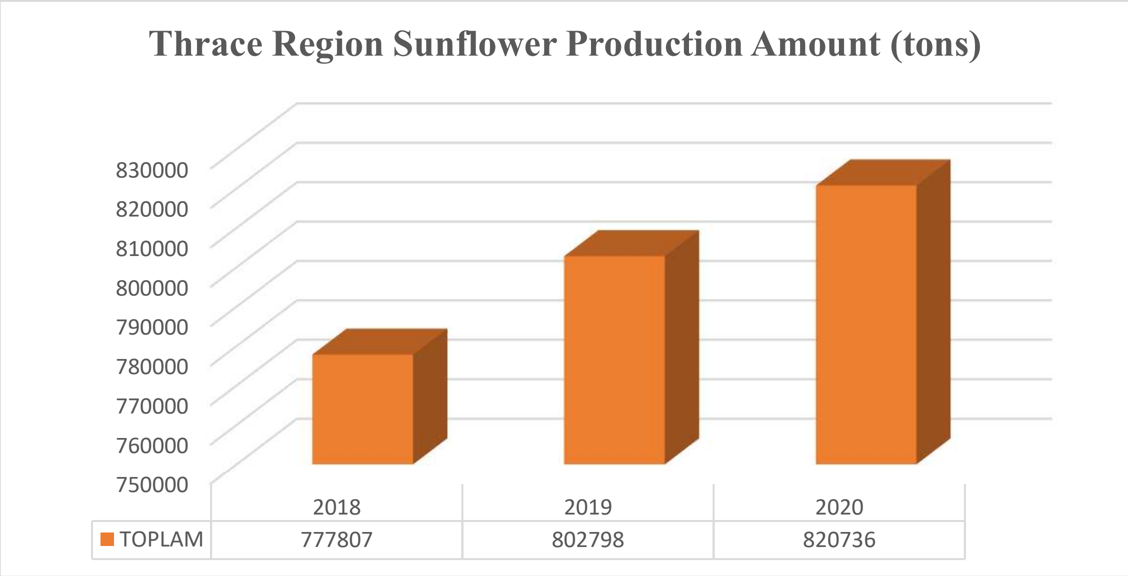


Figure 5. Thrace Region Sunflower Production Amount (tons) (Source: TurkStat, 2020)

2.3. Investigation of Sunflower Yield Averages in the Thrace Region

If we look at the average yield of sunflower obtained from the decares of the Thrace Region compared to the last three years, it is possible to see an increasing graph. While the producers of the Thrace Region, which is the important sunflower cultivation region of our country, obtained an average yield of 247 kg from the decares in 2018, it is possible to say that this figure reached 266.3 kg / da in 2019. However, the fact that the average yield in 2020 was up to 267.7 kg / da is pleasing for our country with sunflower deficit.

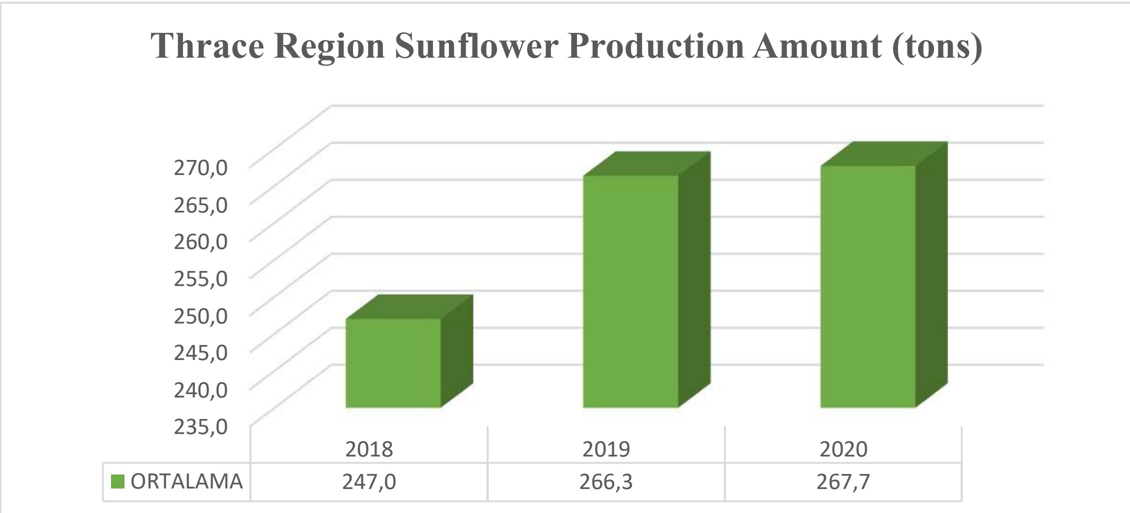


Figure 6. Thrace Region Sunflower Production Amount (tons) (Source: TurkStat, 2020)

When the cultivation areas and production performance of the Thrace Region are examined, it is possible to attribute the increase in the total amount of production to the increase in yield per unit area, especially despite the unbalanced cultivation areas. Especially in 2019 and 2020, the fact that the climatic conditions are suitable for the sunflower plant has caused the yield scale and accordingly the production amount to increase.

2. MATERIAL AND METHOD

The main material of the study consists of primary data obtained from questionnaires carried out at the producer level. In addition, statistical data and literature studies related to the field were also used.
Within the scope of the research, a total of 38 producers engaged in sunflower production within the scope of the Thrace Region area were interviewed. The data collection method was carried out face-to-face and online survey application.
In the questionnaire form used in the study, questions related to the demographic characteristics of the producers, production and product decision selection, production problems, producer satisfaction and evaluation were included. Open-closed-ended and multiple choice question formats were used in the questionnaire form and a total of 32 questions were included. In the analysis and evaluation of the data, simple descriptive statistics were used.

4. RESULTS AND DISCUSSION

4.1. General Profile of the Producers Participating in the Study

4.1.1. Gender, Marital Status, Education Status

When we look at the producers who participated in our survey study, it is possible to say that men are the majority in terms of gender distribution. 91.7% of the participants were male and 8.3% were female.

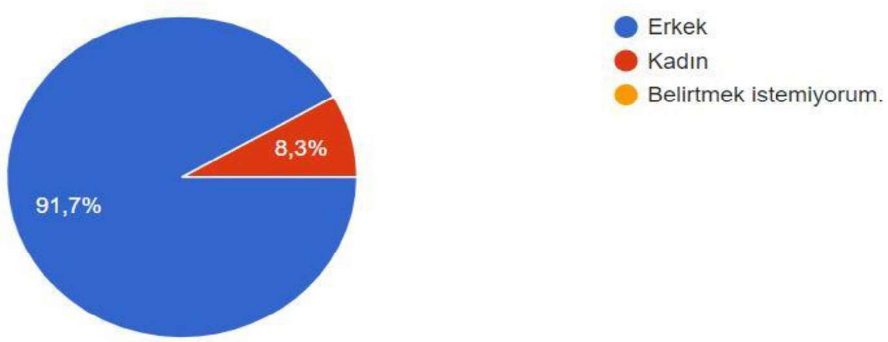


Figure 7. Gender Distribution of Producers Participating in the Study

When the producers who participated in our survey are examined, it is possible to see that 70.8% are married and 25% are single.

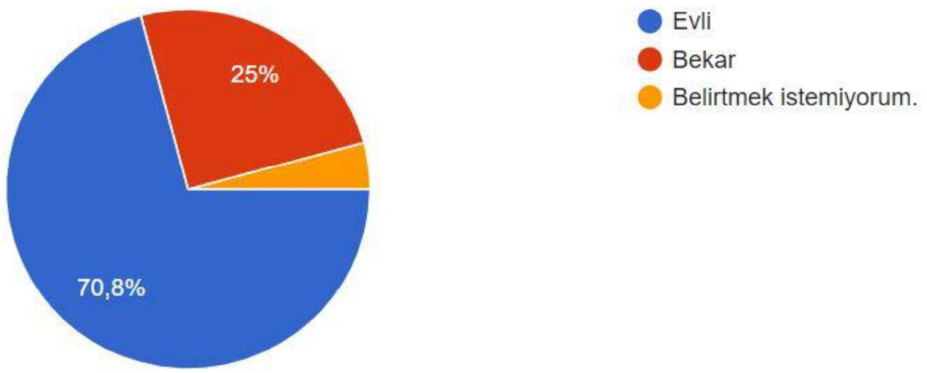


Figure 8. Marital Status Distributions of the Producers Participating in the Study

When the educational status of the producers participating in our survey is examined, we see that 50% of the producers participating in the survey are undergraduate graduates. However, it is seen that the other largest audience consists of producers who have completed their high school education with 20.8%. It is seen that 16.7% of them are Associate Degree graduates. As we can clearly deduce from this table, we can clearly communicate that our survey was attended by more conscious producers who had received a certain level of education, whose educational status was at the medium and high level.

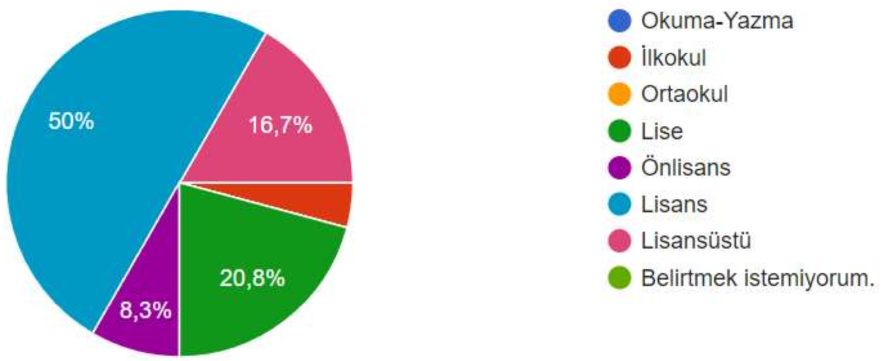


Figure 9. Educational Status Distributions of the Producers Participating in the Study

4.2. Approach to Problems in the Production Process

With the questions we asked our farmers who produce sunflowers in the Thrace Region, we put forward approaches to the problems they experienced in the production process. To the question of what is the biggest problem in agricultural production that we have directed to our producers, our producers have pointed out high input costs with a large majority. 91.7% of the producers emphasized that the biggest problem in production is the high input costs. While the second place was taken by the Disease and Pest answer with 4.2%, marketing problems were pointed out with 4.2%.

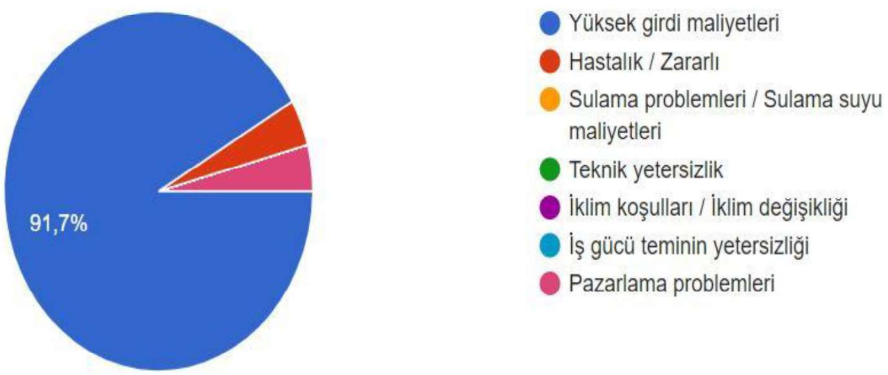


Figure 10. Problems Seen by the Producers Participating in the Study in Agricultural Production

In order to evaluate the difficulties experienced by our producers in sunflower production and their expectations in the face of the problems, we included in our research what is the first responsible or problem element that comes to mind when they experience low yield in sunflower production.
As a result of our investigations, the climate seems to be the first factor that producers hold responsible for the yield losses they experience with a rate of 62.5%. The fact that our producers' concerns and opinions on climate are in this direction is perhaps extremely important in terms of nature sensitivity. On the other hand, it is striking to say that our producers see the second biggest element as the seed variety. Here it is possible to infer that producers have high expectations from seed varieties.

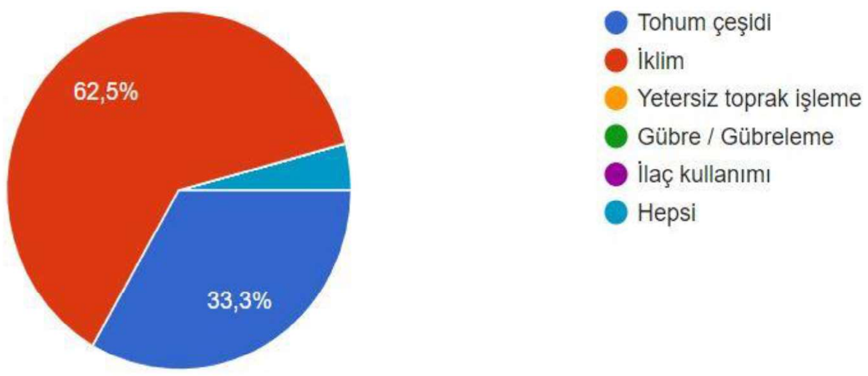


Figure 11. The Perspective of the Producers Participating in the Study on the Productivity Decreases They Experienced

4.3. Factors Determining Sunflower Production Preference

Our producers who produce sunflowers in the Thrace Region are affected by some resources and situations before deciding on the product they will grow. Here, too, when deciding which species the producers will grow, the largest proportion of the producers and 50% of the producers see it as completely the adaptation of the area to be produced to the plant. Secondly, when our producers make production decisions, it is seen that they look at how profitable the product they will grow will provide them. This rate is not to be underestimated and is around 41.7%. One of the striking results of the study will be that when producers make production decisions, they are not affected by other producers at all.

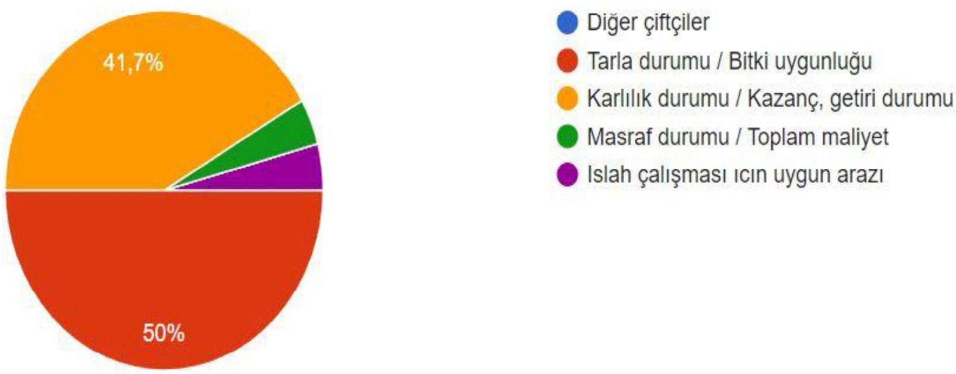


Figure 12. Factors Affecting the Production Decision of the Producers Participating in the Study

In our research, our manufacturers are aware of the problems experienced during production. or it is seen that there are sales channels with the highest rate as the unit and place consulted in the pre-production decision stage. 41.7% of the producers consult the sales channels, dealers or cooperatives first when they need to make decisions in the technical sense or in the problems experienced. Secondly, it is seen that producers are seriously affected by other producers. It was seen that 25% of the producers were determined to be the producers in their environment as consults or samplers. We see that another element is the Agricultural Consultants. When we look at this issue and sum it up, it is seen that the vast majority of manufacturers are inclined to receive support from expert professionals.

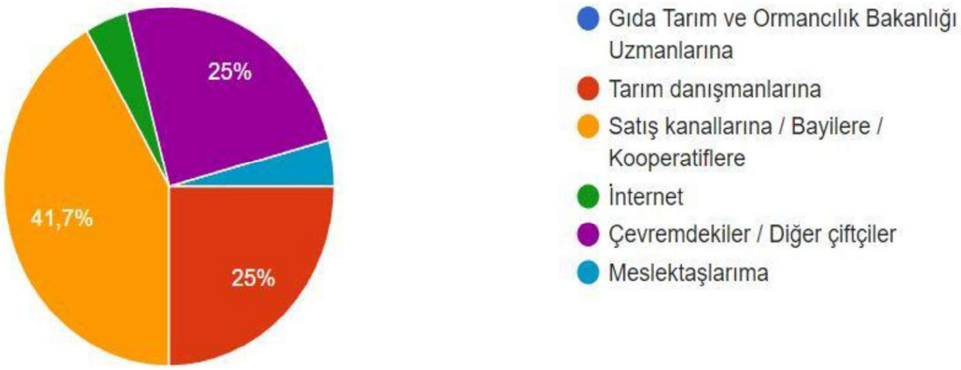


Figure 13. Areas Consulted by the Producers Participating in the Study in Production Problems

4.4. Factors in Sunflower Seed Selection

It is useful to consider separately the issue of seed, which is the most important element of production and which producers especially focus on in our study. We will examine the areas where our producers are affected when making their seed preference and the processes in the decision stages.
When we look at the price evaluation when choosing the sunflower seeds of the sunflower producers of the Thrace Region, 54.2% of our producers emphasized that the price is important for them. In addition, our generator rate, which states that price is very important, is at the level of 16.7%. Our producer rate, which does not care about the price policy in sunflower seed preference, is 16.7%.

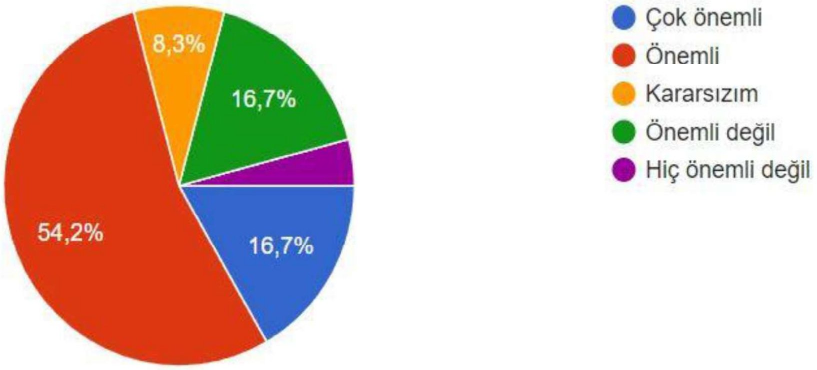


Figure 14. The Importance of Price in the Seed Preference of the Producers Participating in the Study

Producers who produce sunflowers in the Thrace Region are absolutely guided by sales channels and play a decisive role especially in seed preference. When choosing sunflower seeds, our producers consider the guidance of dealers or all other sales channels to be important by 50% and very important by 8.3%. The rate of producers who do not care about the guidance of sales channels remains at the level of only 4%.

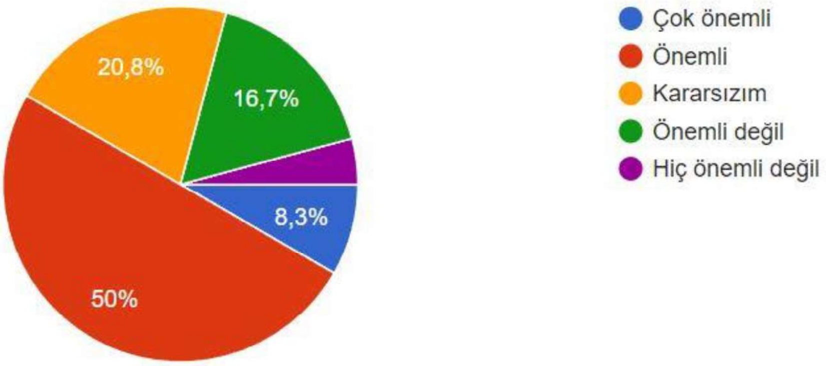


Figure 15. Attitude of the Producers Participating in the Study Towards the Sales Channel Proposal in Seed Preference

4.5. Sunflower Producer's Perspective on Agricultural Policies

Sunflower species is one of the products that have great importance for our country and should be supported as an externally dependent country, especially in terms of oil deficit. Currently, when our country is examined in terms of agricultural policies, certain species and plants; fertilizer, diesel and additional additional supports are given.

In our study, we examined the satisfaction of our producers with the support provided to them in terms of agricultural policy in sunflower agriculture.
To put forward the perspective of the sunflower producers of the Thrace Region on sunflower agricultural supports, 75% of the producers stated that they were not satisfied with the agricultural supports available in the current situation and that the agricultural supports were not sufficient. On the other hand, 20.8% of the producers stated that they were satisfied with the existing sunflower production supports.

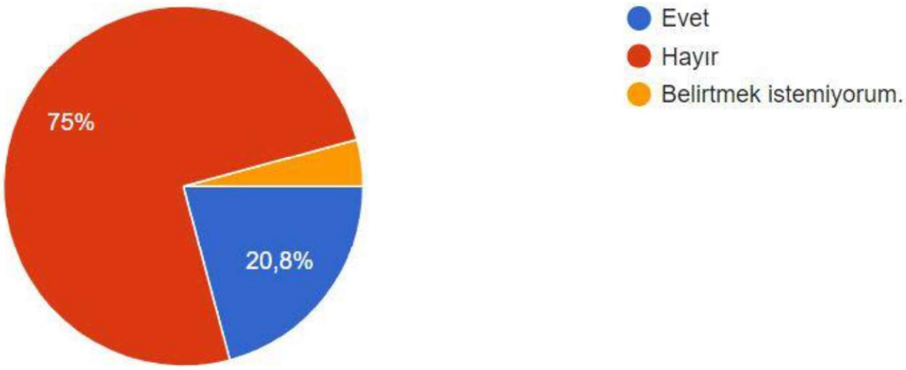


Figure 16. Perspective of the Producers Participating in the Study on Sunflower Production Supports

In addition to the answers given by the producers during the field studies we carry out, it is necessary to evaluate the comments they give to agricultural policy studies. During the face-to-face survey studies conducted in Tekirdağ, Edirne and Kırklareli provinces, it was seen that the producers were highly dissatisfied with the diesel and fertilizer support program currently available in our country. As a result of the study, it is shown that 75% of the producers are not satisfied with the support of the current agricultural policies on the sunflower producer.
Accordingly, in our study, we investigated how manufacturers determine their payment methods as a result of insufficient supports. Here, too, we went to analyze what our producers prefer as a payment method.
It has been observed that 75% of the sunflower producers of the Thrace Region make futures purchases to pay their agricultural inputs and apply to the long-term open account payment method, which we call credit. While 16.7% of the producers apply for installment by credit card, it is seen that only 8.3% of the producers can receive their agricultural inputs in advance.
In this analysis, it is observed that the existing sunflower agricultural supports do not allow the producers to receive their agricultural inputs in advance and the producers to make the biggest expense items more economical with cash purchases.

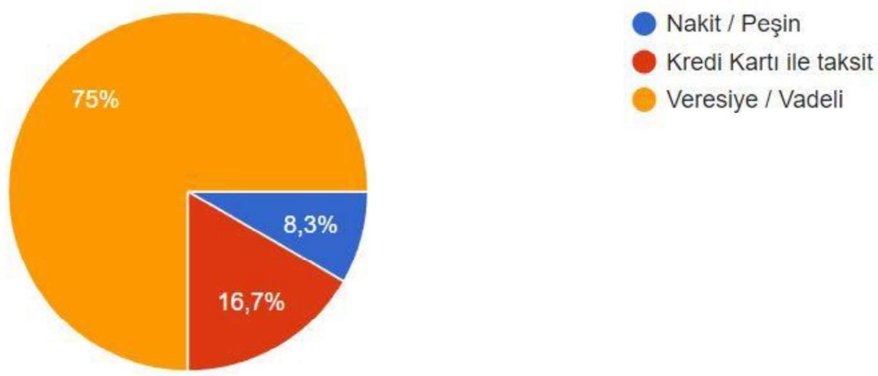


Figure 17. Methods of Purchasing Agricultural Inputs of Producers Participating in the Study

5. CONCLUSION AND RECOMMENDATIONS

It is obvious that our country is a serious importer of sunflower construction. However, in our Thrace Region, which is the largest region where sunflower production is made, it is seen that a total of 3,111,888 sunflower production is made in 2020. The average yield of 267.7 kg / da is obtained against this area. In the light of this area and yield result, 820.836 tons of sunflower products were produced in the Thrace Region.

When the habits and attitudes of our producers are examined, it is seen that the producers are mainly in close relations with sales channels. Our study shows that with this habit, manufacturers also receive serious support from sales channels in planning their commercial activities. In fact, this is a contentious development. It is clearly established that when deciding on the agricultural actions of producers, they consult expert knowledge, demand guidance at a certain rate.

On the other hand, the fact that the sunflower producers of the Thrace Region see the first reason for their yield losses as climate is a source of satisfaction. The fact that producers are aware of yield losses as a result of changing climate, increasing temperatures and droughts continues to hope that it will make producers more sensitive to climate and nature.

The Thrace Region is quite difficult for sunflower producers from the high cost of agricultural inputs. The results of our study clearly show that producers draw attention to input costs as the biggest factor that forces agricultural production. However, the result of caring about price parity in sunflower seed preference supports this idea.

It is observed that the producers of the Thrace Region are not satisfied with their support for sunflower agricultural policy. The vast majority of producers find their agricultural support insufficient. As a result of this situation, we see that a large part of shopping habits are realized as maturity, long-term borrowing.

Agricultural support for sunflower and sunflower oil, which have a high strategic importance for our country, should be increased. Incentives and encouraging support should be provided to our producers for the sustainable production of such a strategic product. The supports to be realized should support the inputs of sunflower producers in real terms and direct production.

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EFFECT OF GENE DOSE ON BROOMRAPE RESISTANCE IN SUNFLOWER

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ABSTRACT

Increasing the genetic resistance of sunflower to broomrape using various approaches attracts breeders from different seed companies. In our work, we studied the effect of the homo- and heterozygous state of the *Or7* gene on the degree of resistance to broomrape race G in 12 sunflower breeding genotypes. The resistance was assessed under the conditions of a climatic chamber in the phase of 3 pairs of true leaves in a box with peat soil for growing plants with the addition of 0.2 g of broomrape seeds per 1 kg of soil. Five homozygous susceptible genotypes (*or7or7*) showed the degree of damage from 14 to 38 broomrape nodules per plant. For two resistant homozygous genotypes (*Or7Or7*), the infection rate was 2 nodules per plant. Five heterozygous genotypes (*Or7or7*) were characterized by a wide variation in broomrape damage values from 2 to 29. Therefore, depending on the combination of crossing, the *Or7* gene in the heterozygote was dominant, intermediate, and recessive. The data obtained indicate the presence of other mechanisms of resistance to broomrape race G, additional to the *Or7* gene.

Key words: heterozygote, homozygote, genotype, seed, race, dominant, recessive

GENETIC DIVERSITY ANALYSIS OF BROOMRAPE (*OROBANCHE CUMANA*) POPULATIONS IN SUNFLOWER GROWING AREAS IN EUROPE

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ABSTRACT

Orobanche cumana or broomrape is an obligate root parasite of sunflower (*Helianthus annuus*) that strongly impacts yield in southern and eastern Europe. The host-parasite system of *O. cumana* and sunflower is characterized by a typical gene-for-gene interaction. The extensive use of sunflower varieties carrying monogenic resistance genes enhanced the selection pressure on the parasite, leading to the emergence of new races. The two most recent races of *Orobanche* that were officially described are referred to as race F and G. This work reviews the results of monitoring broomrape populations in 8 different European countries during the past 10 years. Seeds of *O. cumana* collected in sunflower fields were tested for their virulence on a differential set of sunflower varieties carrying different resistance genes. Race F is still the most predominant in most regions, but in east European countries a wider diversity of races and an increased incidence of the more aggressive race G was observed. The genetic diversity of the isolates was studied using a set of 180 SNPs that allowed to classify them according to their geographic origin and showing higher levels of heterozygosity in eastern Europe populations. These results will be corroborated by more recent GbS data that were obtained for a subset of the collection. All in all, this study provides an overview of the pathogenicity profiles and the molecular diversity of *O. cumana* populations across the major sunflower markets in Europe.

Key words: Sunflower, *Helianthus annuus*, Broomrape, *Orobanche cumana*, genetic diversity

DNA MARKER FOR MARKER-ASSISTED SELECTION FOR SUNFLOWER RESISTANCE TO RACE G OF BROOMRAPE

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ABSTRACT

For marker-assisted selection of sunflower for resistance to race G of broomrape, 2 new SCAR markers have been developed to identification the *HaOr7* gene. The marker RORS1 is for the presence/absence of the *HaOr7* gene with the length of the specific PCR product ≈ 168 bp and the SORS9 marker is for the presence/absence of the wild-type allele with the length ≈ 217 bp. Due to the possibility of multiplex PCR, these markers form a codominant marker system. This marker system was tested on 69 sunflower genotypes with different resistance to broomrape race G: 18 resistant and 34 susceptible lines of VNIIMK breeding, 3 resistant and 10 susceptible hybrids of VNIIMK breeding, 2 differential lines to race F of broomrape – LC1093 and P96 and 2 resistant commercial hybrids SI Chester (Syngenta, Switzerland) and P64LC108 (Pioneer Hi-Bred International, Inc., USA). All resistant sunflower lines to race G of broomrape showed the presence of only one specific PCR product of ≈ 168 bp in length (marker RORS1), characterizing them as homozygotes by the *HaOr7* gene. All susceptible lines, including two differential lines to race F as well as susceptible sunflower hybrids, showed the presence of a specific PCR product of only the SORS9 marker, a wild-type homozygote. Resistant hybrids, including SY Chester and P64LC108, were characterized by the presence of both fragments of the RORS1 and SORS9 markers, making them heterozygous. The marker was used to select sunflower plants from segregating populations at the Laboratory of genetics of VNIIMK. Phenotypic analysis, confirmed that all plants identified by the marker as susceptible were affected by broomrape, while resistant homo- and heterozygotes were not affected or were affected insignificantly – 1–3 tubercles per plant. Thus, the marker we developed is a good tool in sunflower breeding for resistance to race G of broomrape.

Key words: DNA marker, sunflower, Helianthus annuus, broomrape, orobanche cumana, marker-assisted selection

WILD *HELIANTHUS* SPECIES AS A VALUABLE BREEDING SOURCE FOR BROOMRAPE RESISTANCE OF CULTIVATED SUNFLOWER (*HELIANTHUS ANNUUS* L.)

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ABSTRACT

Sunflower is an important industrial crop. Together with the expansion of the production areas, the challenges in growing sunflower are becoming tougher. Undoubtedly one of the most important problems in sunflower cultivation is the parasitic plant broomrape (*Orobanche cumana*). The first use of wild *Helianthus* species for introduction of broomrape resistance dates from the first half of 20th century when Russian academician Zhdanov developed resistant sunflower genotypes from interspecific crosses with *H. tuberosus*, *H. mollis* and *H. maximiliani*. Taking into account the ability of broomrape to evolve into more aggressive races and thus overcome the resistance genes, scientists are forced to constantly search for new sources of resistance. As a result, sources with different levels of resistance are found in *H. tuberosus, H. mollis, H. maximiliani, H. nuttalii, H. debilis, H. neglectus, H. niveus, H. argophyllus*, *H. divaricatus, H. bolanderi*, *H. petiolaris, H. praecox, H. deserticola* and *H. grosseserratus*. Breeding for genetic resistance is even more challenging due to the existence of not only large broomrape interpopulation divergence, but also intrapopulation divergence. One of the areas that has not received enough attention is the anatomical characterization of the root of wild sunflower species and sunflower in general. It is known that pre-haustorial resistance to broomrape is determined by the development of physical barriers in host root cell walls, which prevents linkage of broomrape to the host. A detailed anatomical characterization of root in wild *Helianthus* species can give valuable information about differences between the species and more knowledge about the nature of resistance of certain *Helianthus* species to broomrape.

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Crops - Climate Crops, Institute of Field and Vegetable Crops, Novi Sad, Serbia,, and the by the European Commission through Twinning Western Balkans project CROPINNO, grant number 101059784.

Key words: Wild sunflower, broomrape, resistance

IN THE RACE WITH THE BROOMRAPE - IS THERE A WINNER?

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ABSTRACT

Broomrape (*Orobanche* spp.) is a widespread, herbaceous, parasitic plant that has been known to attack various host plants, including sunflower (*Helianthus annuus* L.). It is native to regions in Europe and Asia, and it co-evolved with various host plants and with the expansion of agriculture and the movement of crops around the world, broomrape was unintentionally transported to new areas. Newer studies report about sunflower broomrape detection in African countries such as Tunisia and Morroco. After the discovery of broomrape infestations on sunflower, various control and management strategies have been developed to combat its spread which includes crop rotation, use of resistant sunflower genotypes, herbicide use and other cultural practices aimed at reducing the prevalence of broomrape. Since it appereance on sunflower in the beggining of the 20th Century and development of resistant sunflower varieties, broomrape control was mostly focused on using resistant genotypes with monogenic inheritance. With the expansion of resistant sunflower genotypes in the production, existential pressure on broomrape led to the emergence of more virulent physiological races. Broomrape races are designated with letters, from A to H, and until the middle of 1990s broomrape race E was predominant in the most countries were broomrape was present and was successfully controlled by resistant gene *Or5*. However, studies from the last several years indicate disimilarities between broomrape populations with the same letter (above race E) reported in different countries. Newer molecular studies are focused on detecting quantitative trait loci (QTLs) which may act at different development stages of broomrape, providing accumulative resistance mechanisms in order to ensure more durable protection. Despite efforts to control broomrape, it remains a persistent problem in sunflower cultivation in certain regions. New strains of broomrape may emerge, making control measures an ongoing challenge for breeders and farmers. Research and development efforts are ongoing to find more effective and sustainable ways to manage this parasitic plant and protect sunflower crop.

Acknowledgment: This work is supported by the Ministry of Education, Science and Technological Development of Republic of Serbia, grant number 451-03-68/2022-14/ 200032, by the Science Fund of the Republic of Serbia, through IDEAS project

"Creating climate smart sunflower for future challenges" (SMARTSUN) grant number 7732457, by Center of Excellence for Innovations in Breeding of Climate-Resilient Crops - Climate Crops, Institute of Field and Vegetable Crops, Novi Sad, Serbia,, and the by the European Commission through Twinning Western Balkans project CROPINNO, grant number 101059784.

Key words: sunflower, broomrape races, quantitative trait loci

STUDY THE RESPONSE OF DIFFERENT INTERSPECIFIC SUNFLOWER FORMS TO PEG-MEDIATED WATER STRESS

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ABSTRACT

Response of five sunflower genotypes with different origin to drought stress at germination and seedling stage was investigated using polyethylene glycol (PEG 6000) as drought simulator under laboratory conditions. Normal treatment and two levels of osmotic stress were monitored. Germination percentage, root length, shoot length, root to shoot length ratio, and depression were determined for the studied genotypes, represented by three replications to evaluate the response of sunflower variety, cultivated hybrid, two interspecific hybrids and an accession of *H. argophyllus* under normal and simulated drought stress treatments. Plant height for all studied hybrids decreased with increasing water stress. Studied interspecific hybrids showed similar responses at osmotic potentials of both -0.6 MPa and -1.62 MPa. They performed better and were classified as drought tolerant. The cultivated sunflower hybrid Baikal showed medium tolerance and variety Favorit – sensitive one. The variation among studied genotypes was found to be a reliable indicator to screen the drought tolerant ones at primary growth stage.

Key words: Interspecific hybrids, osmotic stress, PEG 6000

CLIMATE-RESPONSIVE APPROACHES FOR BUILDING DURABLE RESISTANCE OF SUNFLOWER TO BROOMRAPE IN EVOLVING ENVIRONMENTAL CONDITIONS

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ABSTRACT

The presence of various biotypes of broomrape (*Orobanche cumana* Wallr.), each differing in their virulence towards sunflower (*Helianthus annuus* L.), has been widely documented. Highly virulent races of broomrape (F, G and H) have been observed in numerous sunflower cultivation regions. It is important to note that biotypes of *O. cumana* belonging to the same race can exhibit varying levels of virulence; for instance, race F from Spain may differ significantly from race F in Romania. In light of these variations, conducting systematic multi-environmental testing on available germplasm becomes crucial for identifying stable genetic sources of resistance. The IFVCNS has organized multi-environmental testing to evaluate its breeding material, identifying several resistance genes. Some resistance sources are governed by major genes, while others follow recessive inheritance or exhibit quantitative trait loci (QTL) resistance. Managing broomrape in sunflower production poses challenges due to the parasite's ability to adapt and overcome existing resistance mechanisms. Climate change is considered as a potential factor behind the rapid changes in the racial composition of the parasite. Although resistance to *O. cumana* is frequently breached, utilizing multiple resistance sources is crucial in combating the emergence of new races. While resistance based on a single gene can be easily transferred to elite breeding material and prove effective in the short term, achieving durable resistance necessitates the combination of different resistance genes from diverse sources, including both quantitative and qualitative modes of resistance. Consequently, the incorporation of multiple resistance genes into a single genotype has demonstrated improved resistance durability. Moreover, it is essential to ensure that these genes do not have adverse effects on other desired traits. By capitalizing on the strengths of durable resistance approach, the breeding team at IFVCNS has successfully developed sunflower hybrids with enhanced broomrape resistance and increased sustainability. These advances contribute to sunflower production systems' long-term success and stability, ultimately mitigating the challenges posed by broomrape and changing climatic conditions.

Acknowledgment: This work is supported by the Ministry of Education, Science and Technological Development of Republic of Serbia, grant number 451-03-68/2022-14/ 200032, by the Science Fund of the Republic of Serbia, through IDEAS project "Creating climate smart sunflower for future challenges" (SMARTSUN) grant number 7732457, by Center of Excellence for Innovations in Breeding of Climate-Resilient Crops - Climate Crops, Institute of Field and Vegetable Crops, Novi Sad, Serbia,, and the by the European Commission through Twinning Western Balkans project CROPINNO, grant number 101059784.

Key words: sunflower, broomrape races, genes, resistant hybrids, durability

RACES OF BROOMRAPE PRESENT IN SOUTH-EASTERN ROMANIA

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ABSTRACT

In countries around the Black Sea, such as Romania, Bulgaria, Turkey, Ukraine, Russia is present the most virulent races of broomrape (*Orobanche cumana* Wallr). In soth-east of Romania, in location Braila, in years 2022 and 2023 we identify races A, B, C, D, E, F, G, H, I or more. In every year we tested differential set with sunflower genotypes for identified races of broomrape present in this area. In flowering time of sunflower genotypes, we make notation about attack degree of broomrape and we observe a higher virulence in year 2022 then in year 2023. An additional differential genotype, old Romanian variety Neagra de Cluj (accession PI 650368), was resistant at broomrape race HRO or IRO in both years. Neagra de Cluj, can be included in international set of differential for races G, H and I of parasite *Orobanche Cumana* and is provided by North Central Regional Plant Introduction Station (NCRPIS), part of United States National Plant Germplasm System (NPGS).

Key words: sunflower, broomrape, races

NEW APPROACHES FOR ACHIEVING DURABLE RESISTANCE TO BROOMRAPE IN SUNFLOWER

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ABSTRACT

Sunflower broomrape (*Orobanche cumana* Wallr.) is a holoparasitic plant that causes significat yield losses to sunflower crops. Hence, the development of broomrape-resistant hybrids is one of the prime breeding objectives. Using conventional plant breeding methods, resistance genes have been identified which led to the development of a number of resistant hybrids, adapted to different growing regions worldwide. However, while there are many studies on genetic of resistance to broomrape in sunflower, the molecular tools that are available for research on *O. cumana* are very scarce. Recent advances in sunflower genomics pawed the way for application of modern breeding tools in broomrape breeding and find durable solutions for limiting broomrape spread and virulence. Here we present an overview of those new tools, such as phenotyping, -omics, and genome editing techniques, which need to be introduced into the sunflower breeding programs in order to achieve durable resistance to this parasitic plant.

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Key words: sunflower, broomrape, new breeding tools, durable resistance

A PRELIMINARY STUDY ON THE IDENTIFICATION OF DIFFERENT SUNFLOWER VARIETIES WITH THE LEVEL OF RESISTANCE TO RACE G MINOR SPECIES AN

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ABSTRACT

Orobanche cumana has become a bottleneck factor restricting the healthy development of the sunflower industry in China. Planting sunflower varieties resistant to broomrape is the simplest, feasible, and cost-effective control measure at present. It is important to clarify the mechanism of sunflower resistance for breeding resistant varieties to broomrape. In this study, we used the petri dish filter paper system to edaluate and identify the resistance level of 32 sunflower varieties. We selected two sunflower varieties (JK103 and LD5009) with significant difference in resistance and sensitivity level. After artificial inoculation of the G race, the differences in the number of parasitic nodulation on roots, callose deposition in cell wall, hydrogen peroxide accumulation, ROS scavenging enzyme activity and transcription expression of resistance genes between resistant and susceptible varieties were compared at germination stage, nodulation stage and shoot meristem stage. The results showed as follows: (1) The average number of parasitism tubercle in the roots of JK103 was 3.2, significantly lower than that of LD5009, which was 16.2; The callose mass deposited in the root cell wall of JK103 was significantly higher than that of LD5009; The content of hydrogen peroxide and the activities of different ROS scavenging enzymes in the roots of JK103 and LD5009 showed an initial trend of increase and then later decreased. The magnitude of the changes of the above indicators in the roots of JK103 was significantly higher than that of LD5009 at the same time point; The quantitative transcription level results of the resistance-related genes showed that, except *XTH6*, the relative expression content of all tested resistance-related genes, such as *Ha-PR1*, *LOX*, *CAT*, etc. in resistant variety JK103 was significantly higher than the susceptible variety LD5009. The above results suggested that sunflower against the infection of broomrape via structural and physiological resistance mechanism, meanwhile, the signal molecules,

such as H_2O_2, JA and SA were also involved in the establishment of sunflower resistance upon the infection of broomrape.

Fund Project: National Special Oil Industry Technology System（CARS-14）

Key words: *Orobanche cumana*; resistance gene; hydrogen peroxide content; antioxidant enzyme activity

APPLICATION OF SSR MARKERS TO REVEAL THE GENETIC DIVERSITY OF SUNFLOWER BROOMRAPE IN CHINA

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ABSTRACT

Broomrape (*Orobanche cumana* Wallr.) is a kind of parasitic seed plant seriously affecting the sunflower industry in China. To clarify the genetic relationship of sunflower broomrape in China, SSR markers were used to determine the population genetic diversity of 93 broomrape samples which were collected from different provinces of China. Results showed 14 SSR primers were screened out from 50 SSR primers, based on their highly polymorphism among tested samples. A total of 108 out of 112 bands were identified as polymorphic bands. The percentage of polymorphic bands was 96.43%. Both Shannon index and Nei′s diversity index were raised with these ample population size increasing. Among tested samples, broomrape collected form Inner Mongolia and Xinjiang provinces showed most highly polymorphism. Their Shannon indices were 0.4380 and 0.4967 respectively. Genetic clustering results showed that the samples from 6 different provinces could be divided into 2 clades. Inner Mongolia, Yunnan, Xinjiang, Hebei and Gansu samples were clustered into one clade, and Shanxi were clustered into another separated clade. Samples collected from Gansu and Shanxi province showed the closest relationship, while the same samples from Gansu showed the furthest relationship with samples collected from Xinjiang region.

Funding Project: China Agricultural Research System (CARS-14). The Research Start-up Funds for High-level Researchers in Inner Mongolia Agricultural University (NDYB2019-2). Integration and demonstration of green prevention and control technologies for sunflower crops in arid and cold mountainous areas(2022YFXZ0039)

Key words: Sunflower, *Orobanche cumana*；SSR markers；genetic diversity

DEVELOPMENT CRISPR/CAS9-MEDIATED RESISTANCE IN SUNFLOWER AGAINST *O. CUMANA*

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ABSTRACT

Sesquiterpene lactones (STL) are a group of natural compounds found in various plant species, including sunflowers (Helianthus spp.), and they have been studied for their potential role in allelopathy and defense against pests and pathogens. Allelopathy refers to the ability of certain plants to release chemicals that affect the growth and development of neighboring plants and organisms. In the context of sunflower broomrape (Orobanche cumana) and sunflowers, STLs have been of particular interest due to their potential role in inhibiting the growth of the broomrape parasite. Some STLs have been shown to possess allelopathic properties, which means they can influence the germination and growth of other plants, potentially including parasitic plants like sunflower broomrape. Research has suggested that certain STLs found in sunflowers may exhibit inhibitory effects on the germination and growth of sunflower broomrape seeds. These compounds could potentially be released from the sunflower roots and into the soil, creating a hostile environment for the parasite. However, the effectiveness of sesquiterpene lactones in controlling sunflower broomrape is still an active area of research, and their practical application as a management strategy requires further investigation. In recent years, secretion of Sesquiterpene Lactones (STLs) from sunflower roots has been found to trigger the germination of broomrape seeds. The genes encoding the enzymes (*HaGAS, HaGAO, HaG8H, HaCOS*) functional in STL biosynthesis in sunflower have been well characterized. CRISPR-Cas9 is a powerful genetic editing tool that has been used to modify specific genes in various organisms, including plants, for a range of purposes, including crop improvement and pest resistance. In the light of all these information, genes of the enzymes that catalyze the production STLS was aimed to knockout with CRISPR/Cas9 technique in the study. It has been hypothesized that mutant sunflower lines developed in this way will have full resistance to broomrape. The sequences of four genes (HaGAS, HaGAO, HaG8H, HaCOS) encoding the enzymes functional in STL biosynthesis were retrieved from the database and processed with CRISPR-P 2.0 software to find out the best guide RNAs (gRNAs) that can target exon parts of the genes. By this way, four best gRNAs (one gRNA for each gene) were selected for simultaneous targeting of the first exon of the

genes. All gRNAs were then transferred into a Cas9 containing agrobacterium plasmid (pHSE401) by using golden gate cloning. gRNA/Cas9 containing vectors were then inserted into agrobacterium rhizogenes and positive colonies were verified with colony PCR. The seed, cotyledon and hypocotyl explant of the sunflower genotype (NS3) was then treated with A. rihizoneges to insert of the gRNA/Cas9 into explants and root formation. Rooted mutants' explants were then put into broomrape seed containing tissue culture media. The results indicated that 79% of the mutant roots have high resistance to broomrape. After DNA isolation, the target genes were amplified with PCR and sequenced to see the CRISPR-mediated mutation in the genes. among the broomrape resistant rooted explants 83% of them were recorded to carry mutation in the gene of interest. This is the first study developing broomrape resistant sunflower genotypes by using CRISPR genome editing system. Optimization of CRISPR mediated gene transfer and regeneration protocol will fasten and made important contribution to sunflower breeding. Genome editing-based strategies used to enhance crop resistance to parasitic weeds and its prospective applications will be discussed in the congress.

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Key words: CRISPR, Sunflower, Sesquiterpene Lactones, broomrape, *O. cumana*, resistance

INFLUENCE OF BROOMRAPE ON SOME ANATOMICAL AND PHYSIOLOGICAL TRAITS IN SUNFLOWER

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ABSTRACT

Parasitic species of *Orobanche* are totally depend on their host for all nutritional requirements, drawing nutrients from host plants via a specialized structure named haustorium. *Orobanche cumana* is a specific parasite of sunflower (*Helianthus annuus* L.) that can cause reductions in crop yield and different yield associated traits, such as head diameters, weight of 1000 achenes, number and weight of seeds per head etc. Here, we evaluate the influence of broomrape on some anatomical and physiological traits in host. Plant height, leaf area, content of pigments (chlorophyll a and b, carotenoids etc.), as well as crop yield of some sunflower hybrids susceptible to the parasite were analysed in two infested and non-infested fields during 2021 agricultural season. In different fields the number of broomrape attachments per host plant varied between 0,6 and 5,1 depending on sunflower genotypes. The most affected was the hybrid noted HT3, which shown the lowest value of yield (1,6 t/ha comparative to 3,4 t/ha in control). The yield of infested plants was significantly diminished (by 34-54%, depending on sunflower hybrids) comparative to non-infested controls. In addition to yield losses, broomrape significantly influences sunflower leaf area. So, an increase in leaf area and leaf area index (by 16-59%) in *O. cumana* infested sunflower was found in comparison to non-infected plants, the results being in concordance with those reported by other researchers. Although changes in chlorophyll content also were reported in some plants attacked by broomrapes, in this study, chlorophyll a, chlorophyll b, chlorophyll a + b content and Ca/Cb did not show any significant differences between the infested and non-infested hybrids. No significant correlations were found between the number of *O. cumana* attachments and the degree of damage to the host.

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Keywords: sunflower, broomrape, *Orobanche cumana,* yield, leaf area

THE STIGO PROJECT: DECIPHERING THE MOLECULAR DIALOG OF O. CUMANA SEEDS GERMINATION

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ABSTRACT

Orobanche cumana is an obligate non-photosynthetic parasitic plant that attaches to the roots of the sunflower (*Helianthus annuus*) for acquiring water and nutrients for its development. Broomrapes (up to 100/sunflower plant) are then new sink for sunflower and lead to yield losses. To date, resistant sunflower varieties are the most effective way to control *O. cumana*. However, it is still necessary to understand the underlying resistance mechanisms in sunflower. While the vast majority of plants germinate thanks to internal hormonal signals and environmental cues, broomrape seeds do not germinate spontaneously and must perceive a biochemical signal produced by the host roots that induces the germination. Sunflower is the only cultivated host species for *Orobanche cumana*. To date, only three major resistance genes have been mapped in sunflower and none of them is involved in the induction of *O. cumana* seed germination. However, a better understanding of this key stage in the interaction between the sunflower and *O. cumana* will lead to new control methods. The *LGS1* gene in sorghum is involved in modulating the production of molecules inducing *Striga* seeds germination, enhancing the resistance to *S. hermonthica*, an obligate photosynthetic root parasitic plant. So far, two types of allelopathic signals have been identified, the strigolactones (SL) and sesquiterpenes (eg. dehydrocostus lactone, DHL), but a larger panel of germination stimulant (GS) molecules is expected and remains unknown in sunflower. Our objectives are to develop effective and selective methods of control against *O. cumana by:* (i) identifying the allelochemicals exudated by sunflower and responsible of *O. cumana* seed germination and the genes and alleles involved in their biosynthesis (ii) identifying and characterizing the GS receptor(s) of *O. cumana*, and developing specific germination inhibitors based on their activity towards these receptor(s), (iii) developing new control methods against *O. cumana* and new varieties for sunflowers with low stimulant germination activities.

Key words: orobanche cumana, seeds, sunflower root exudate, germination stimulant, GS receptors

CONTENT AND OIL YIELD OF SUNFLOWER (HELIANTUS ANNUS) - HYBRID DEVEDA DEPENDING ON THE MAIN TILLAGE SYSTEM

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ABSTRACT

The research was conducted in a stationary field experiment of the Dobrudzha Agricultural Institute - General Toshevo in the period 2016 to 2022. The impact of seven main soil tillage systems (MSTS) with and without turning the cultivated layer, No-till, as well as the alternative alternation between them in a 4-field crop rotation (beans-wheat-sunflower-corn) on the content and yield of oil. The MSTS are: 1. CP - conventional plowing (24-26 cm); 2. D – disking (10-12 cm) 3. C – cutting (chisel-plough); 4. NT - No-till (direct sowing); 5. Coventional plowing (for spring crops) – No-till (for wheat); 6. Cutting (for spring crops) - Disking (for wheat) and 7. Coventional plowing (for spring crops) - Disking (for wheat). The mineral fertilization in the crop rotation was as follows: Common bean – N60P60K60; Wheat – N120P120K60; Sunflower - N60P120K120 and Maize – N120P60K60. The main objectives of the study were: (i) to investigate the seasonal variability in sunflower: (i) in the kernal/husk ratio; (ii) the oil content of the whole seed and its components; (iii) the obtained yields of oil per 1 area. The share of the kernel varies from 74.91% (2016) to 80.20% (2018). The highest percentage of oil in the husk was found in 2018. In the whole seed, this high level of differentiation in oil content values depending on weather conditions over the years was preserved. The seed produced in 2019 is the richest in oil (50.85%). Yields of kernels, husks and their oil yields, as well as whole seed, were more strongly affected by weather conditions during the study period compared to the effect of the MSTS. The tillage systems with or no deep turning treatment of the plow layer applied in crop rotation constantly or in combination with shallow tillage or No-till lead to obtaining seed richer in oil concentration and, accordingly, oil yield compared to the others. The independent permanent application of deep cutting (chisel-plough) oil yield is less with 144.7 kg/ha compared to traditional plowing, while in the application of CP-No-till system this difference is only 88 kg/ha. Shallow tillage alone and in combination, as well as long-term self-application of No-till lead to an increase in the share of husks and a lower yield of oil compared to the deep main tillage. The reliability of the obtained results is of the maximum degree of expression. The influence of meteorology as a factor is more pronounced than that of STS. It has approximately the same values for %

kernel/husk in the seed, as well as for the percentage of oil in the kernel and the whole seed. However, it was found to have a much stronger influence on oil concentration in the husk compared to that in the kernel and whole seed. The strict adherence to crop rotation, regardless of the diversity in the main tillage systems tested and the high level of selection work lead to a lack of observation of the blue wrist parasite (*Orobanche ssp*.). An additional contribution to this fact is that the areas in the area are lightly infected with aggressive races of this parasite. The proportion of kernel in the seed is strongly negatively correlated (-0.995**) with that of the husk. The proportion of kernel in the seed was also in a well-pronounced positive correlation with the percentage of oil in the seed (+0.485**) and the oil concentration in the husk (+0.445**). There is also a well-expressed correlation between the oil content of the nut and that of the seed (+0.699**).

Key words: main soil tillages systems, sunflower, kernel/husk components, oil concentration, oil yields

TRANSCRIPTOME ANALYSIS AND GENE MINING OF BROOMRAPE IN SUNFLOWER-BROOMRAPE PATHOSYSTEM

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ABSTRACT

Orobanche cumana (sunflower broomrape), a weedy root parasite, mainly attack sunflower and entirely attract water and nutrition from the host. Broomrape causes severe yield losses of sunflower worldwide, but it is difficult to control by traditional practices because of its complex life cycle. In order to elucidate the molecular mechanism of interaction between sunflower and broomrape, some genes about infestation are being uncovered in broomrape by our RNA-seq analysis. In this study, two sunflower varieties (resistant/sensitive sandaomei strain) were selected and inoculated with broomrape respectively. During the interaction between sunflower and broomrape, broomrape nodule was sampled and transcriptome sequencing was performed. We finally deployed the Deseq2 assay to screen differentialy expressed genes (DEGs) from the broomrape that inoculating in sunflower resistant cultivars and sensitive cultivars respectively. A total of 868 DEGs were obtained, including 437 up-regulated genes and 431 down-regulated genes. The GO enrichment analysis showed that DEGs were mainly enriched in the sucrose/starch metabolic process, cell wall and protein serine/threonine kinase activity. The process of sugar metabolism can affect the osmotic pressure of sunflower broomrape, causing the variation of water content and nutrition in the broomrape derived from host. The enzymes that catalyze sucrose into reducing sugars are located at the cellulose synthesising tissues, mainly in the cell wall. The study of the genes about sucrose/starch metabolic process can provide the detail that how to the enzyme promote the broomrape infesting sunflower, and provide insight into exploiting effective measures to control the weedy parasite.

Key words: Broomrape, Sunflower, Transcriptome analysis, Gene mining, Pathosystem

MECHANISM OF ‘JINMIAO TARGET’ IN INHIBITING *OROBANCHE CUMANA* PARASITISM OF SUNFLOWER

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ABSTRACT

In this study, two different sunflower varieties (LD5009 and JK103) were treated with ‘Jinmiao target’ by root irrigation. The root samples were collected at 0, 24, 48 and 72 h after irrigation for histochemical analysis. H2O2 content, ROS scavenging enzyme activity and resistance related gene expression in roots were measured. The growth index and tubercle number of sunflower were measured 20 days after irrigation. The aim of this study was to elucidate the mechanism of ‘Jinmiao target’ in inhibiting *Orobanche cumana* parasitism of sunflower. The results showed that: (1) compared with the control (water application), the number of tubercles in LD5009Jinmiao target decreased by 95.5 and the parasitism rate decreased by 98.20%, the fresh mass and dry mass of tubercles decreased by 94.60% and 81.63%, the height and stem diameter of sunflower increased by 2.09 cm and 0.52 mm respectively, the growth rates were 14.92% and 15.29% respectively. The number of tubercles in the JK103Jinmiao target reduced by 37.5 compared with the control, the parasitism rate decreased by 98.04%, the fresh mass and dry mass of tubercles decreased by 97.06% and 82.69%, the height and stem diameter of sunflower increased by 2.07 cm and 0.39 mm respectively, the growth rates were 12.26% and 9.70% respectively. (2) After irrigating with ‘Jinmiao target’ inducer, the corpus callosum deposition in the roots of both sunflower cultivars increased. However, the JK103 showed the most significant increase after 48 h. The content of H2O2 after 24 h reached the maximum in JK103 and LD5009 varieties, which were 3.53 and 2.68 µmol·g-1, respectively. Compared to the control, the most significant increase of H2O2 content was recorded in LD5009, an increase of 208.05%. (3) The activities of four ROS scavenging enzymes in two varieties showed an initial trend of increasing and then decreasing, all of them reached the maximum value after 48 h of treatment. Compared with the control, the activities of SOD, POD, CAT, PPO in JK103Jinmiao target treatment increased by 69.77 U·g-1, 5.44 U·g-1·min-1, 1.88 U·g-1·min-1 and 527 U·g-1·min-1, respectively. However, the activities of the above four ROS scavenging enzymes were increased by 25.91 U·g-1, 13.16 U·g-1·min-1, 0.50

U·g-1·min-1 and 313 U·g-1·min-1 in LD5009Jinmiao target treatment. (4) Transcriptional analysis of related resistance genes indicated that the two varieties were induced in different degrees after treatment. However, induction degree of LD5009Jinmiao target was the most obvious, especially CAT, Mn-SOD and XTH6. The relative expression levels were more than 50 times higher than the control. The results showed that the 'Jinmiao target' inducer had significant inhibitory effect on the parasitism of sunflower, the effect was better before parasitizing sunflower (before the formation of tubercles). 'Jinmiao target' inducer could promoted callose deposition in sunflower root cells and resisted the infection of sunflower root by *O. cumana* at the structural level, it also induced the increase of ROS scavenging enzyme activity and the expression of CAT, PAL, Mn-SOD and XTH6 genes in sunflower roots, so that sunflower increased resistance to *O. cumana* parasitism. However, the degree of induction varies from cultivar to cultivar.

Fund Project: China Agricultural Research System (CARS-14).

Key words: Sunflower; *Orobanche cumana*; Jinmiao target; induced resistance

EVOLUTION OF *OROBANCHE CUMANA* WALLR. IN INTENSIVE SUNFLOWER CULTIVATION IN REGIONS OF RUSSIAN FEDERATION

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ABSTRACT

The intensification of sunflower cultivation over the last three decades with reduced crop rotation in regions of the Russian Federation has led to accelerated development of its obligate parasitic plant *Orobanche cumana* Wallr. Annual monitoring of broomrape seed infestation of fields over the last 15 years shows that despite the widespread distribution of race G, seeds of other, weaker races E and F remain in many fields. Seed reemergence of these races in the fields is probably due to the continued cultivation of susceptible sunflower varieties-populations. A highly aggressive parasite biotype (future race H) that overcomes the resistance of the sunflower differentiator line RG, which has immunity to race G, has so far been identified in small numbers in some fields in the Krasnodar, Stavropol, Rostov, Voronezh, Samara, Saratov, and Orenburg regions. Obviously, the continuation of intensive sunflower cultivation in these fields will lead to a rapid spread of race H in these regions. In addition to the racial diversity, frequent changes in plant habitus (bushy forms) were observed in some representatives of race G. For the first time, we have shown an overgrowth of the haustorial-tubercle area of the parasite and the formation of multiple stems from a single tubercle. This creates an advantage in the competition for food between adjacent broomrape individuals on the same sunflower root and ultimately accelerates and increases the seed production of the plant. Thus, the rapid evolution of *O. cumana* during the intensification of sunflower cultivation is expressed not only in the formation of new physiological races, but also in an accelerated increase in the seed productivity of the parasite by changing the habitus of the plants, including the haustorial-tubercle area.

Keywords: Sunflower, broomrape, evolution, race, haustorial area, root thickening, habitus change.

INTRODUCTION

Broomrape (*Orobanche cumana* Wallr.) is of the higher plant taxon and is an obligate parasite that is widespread in most sunflower growing countries and it continues to cause significant losses in sunflower yields (Kaya, 2014; Ma et Jan, 2014; Molinero-

Ruiz et al., 2015; Martin-Sanz et al., 2016; Risnoveanu et al., 2016; Maklik et al., 2018; Dedic et al., 2022; Duca et al., 2022; Zhang X.et al., 2018; Antonova et al., 2022).

In the Russian Federation, sunflower is the main oil crop, highly profitable and therefore attractive for cultivation. Over the last three decades, the sunflower crop acreage in the Russian Federation has increased steadily each year, reaching 10,032,800 ha in 2022. Initially (more than 30 years ago), this crop occupied a total area of 2,322,000 ha throughout the former Soviet Union (Antonova, 2014). This continued rapid increase in crop acreage was only possible when crop rotation was reduced from the scientifically based 8-10 years to 1-3 years. This ongoing phenomenon of short sunflower rotations continues to pose a challenge to broomrape control.

The reduction in crop rotation promoted the acceleration of the mutation process in broomrape, the rapid increase in the frequency of emergence of its new generations, and the expansion of their spread areas. This process led to an increase in the frequency of emergence of new broomrape biotypes capable of overcoming resistance to it in the cultivated sunflower varieties, i.e., accelerated the emergence of new physiological races of the parasite. It also accelerated the formation of new, hereditary fixed traits, which caused an acceleration of the more powerful development of the parasite individual, an increase in its seed productivity and survival under the influence of the human desire to destroy this harmful weed. It should be emphasized that not only coevolution of broomrape and sunflower is observed, but also rapid, hereditary fixed changes in the parasite individuals, which improve their resistance to unfavourable habitat conditions arising under the influence of man.

The aim of our work was to identify the racial origin of broomrape seeds from fields of sunflower growing regions of the Russian Federation and to describe new botanical characteristics in representatives of the most widespread race G of the parasite.

MATERIAL AND METHOD

Identification of racial origin of broomrape seeds collected annually for breeding purposes was carried out using the following sunflower genotypes: hybrid NK Brio (resistant to 5 broomrape races from A to E), line LC 1093 (resistant to race F of the Romanian type, including previous races), line P 96 (resistant to race F of the Spanish type and all previous races), hybrid Tunka (resistant to races A to G) and line RG (resistant to race G and all previous races), developed in the immunity laboratory of V.S. Pustovoit All-Russian Research Institute of Oil Crops. Sunflower variety VNIIMK 8883, which was susceptible to all races of broomrape, was used as a control variant.

The seeds of each broomrape sample were mixed with soil-sand mixture (3 :1) at a rate of at least 200 mg per 1 kg of this mixture and placed in plastic boxes of 50x20x20 cm. Seeds of the above sunflower genotypes were sown in these boxes and placed in the climate chamber Biotron-5. They were grown at a temperature of 25-27 °C, with a 16-hour photoperiod and appropriate lighting.

The seedlings were watered moderately when the topsoil dried out. After 25 days from the seedling emergence, the plants were dug up and the roots were washed with water. The number of tubercles and broomrape shoots on the roots of 20 plants of each differentiator was counted, the average degree of plant affection was calculated and compared with the affection of the control variant (Antonova et al., 2019).

Seeds of broomrape pure race G were collected on sunflower hybrids of foreign breeding containing the Or_7 gene. The presence of this gene in only one of the parent lines of the hybrid (usually in the paternal form) confers incomplete resistance to broomrape race G. Some degree of affection of hybrid plants is observed. The broomrape seeds collected from such affected plants, when identified, always represented race G. (Antonova et al., 2020).

Stereoscopic microscopy was used to observe the early stages of tubercle and shoot formation on the roots of plants of a race G susceptible sunflower variety grown on an infectious background produced from seeds of this race.

RESULTS AND DISCUSSION

Annual monitoring of the racial origin of broomrape seeds collected from sunflower sowings in different regions of the Russian Federation (Samara, Voronezh, Rostov, Orenburg, Volgograd, Saratov, Belgorod, Krasnodar and Stavropol regions) shows that race G is currently widespread. At the same time, however, there are still fields where only races E or F predominate, or where there is a mixture of two or three races with the predominance of one of them. Table 1 shows sample data for selected fields (25 in total) from six regions of the Russian Federation for the period 2020 - 2022. In general, and for the other regions mentioned above but not listed in the table, the picture is similar to the data presented. As can be seen from the Table, race G is now dominant in many fields and its seed admixture is already present where other races predominate.

In the sample of fields for the last three years shown in the Table, the least virulent race E dominates in seven of them. In general, analyses of the racial origin of broomrape seed samples collected in the period 2020-2022 in different regions showed considerable heterogeneity in virulence. Therefore, monitoring the racial origin of broomrape seeds from different fields in the sunflower growing regions of the Russian Federation remains relevant and is a necessary condition for the correct placement of cultivated sunflower varieties, which can slow down the formation of highly virulent biotypes of the parasite in each particular field.

There are several reasons for the current presence of the weaker races E and F in the fields. First, it has long been known that germination of broomrape seeds can persist for up to 20 years under field conditions (Molinero-Ruiz et al., 2008). Secondly, some farms are acting sensibly by trying to maintain a long crop rotation, thus slowing the emergence and spread of more virulent biotypes of the parasite. Thirdly, in Russia, in addition to hybrids, sunflower varieties are traditionally grown on which weaker races of broomrape can reproduce new generations of seeds, thus prolonging their existence in agrocenoses.

However, in each of these regions, there are already fields where the even more virulent biotype H, which has overcome the resistance of the line RG, is accumulating. In total, half of the fields shown in the Table contain this broomrape biotype. It is only a matter of time before such problem fields will accumulate enough seeds of this biotype so to be collected to create a highly infectious background for the selection of resistant sunflower genotypes in immunity breeding.

We observed early stages of tubercle formation in a continuation of our earlier studies on artificial inoculation of sunflower plants with broomrape in an infectious background developed from race G seeds.

Table 1. Degree of affection* of sunflower resistance differentiators by broomrape collected in selected fields of six regions of the Russian Federation in 2020 - 2022.

Broomrape seeds collection area	Susceptible control VNIIMK 8883	Differentiators, resistant to races:					Dominant broomrape race in the seed sample	Admixture of other races in the seed sample
		A-E (NK Brio)	A-F (LC1093)	A-F (R 96)	A-G (Tunka)	A-G (RG)		
Rostov region								
Azovsky	30	12	20	5	6	0	G	E
Zernogradsky	42	41	10	4	3	0.7	F	G, H
Oktyabrsky	38	12	11	3	1.8	0	E	G
Matveevo-Kurgansky	55	48	59	31	15	6,0	G	H
Bokovsky	53	59	36	23	2	0.9	F+ G	H
Voronezh region								
Kalachevsky	41	20	22	9	9	0	G	E
Pavlovsky	36	11	10	5	2	0.7	E	G, H
Novousmansky	31	30	21	16	4	2	F+ G	H
Kashirsky	33	13	6	0	1	0.3	E	F, G, H
Samara region								
Bolsheglushitsky	30	13	21	2	5	0.4	G	E, H
Volzhsky	42	18	28	4	6	0.5	G	F, H
Neftegorsky	34	9	9	5	4	0	E	G
Orenburg region								
Oktyabrsky	30	31	15	0.3	4	0	F+ G	
Plemanovsky	29	28	25	2	3	1	G	H
Buguruslansky	32	0,6	0.4	0.5	2	0	E	G

Kurmanaevsky	51	43	5.5	0.1	2	0	E	F, G
Stavropol region								
Kochubeevsky	38	29	14	9	4	0	E	G
Sovetsky	56	39	23	7	11	1	E+ F+ G	H
Krasnodar region								
Primorsko-Akhtarsky	32	23	22	3	6	05	G	E
Krylovskoy	34	33	30	7	3	0.8	G	H
Vyselkovsky	49	38	30	16	8	0	G	E, F
Brukhovetsky	33	37	18	14	0	4	F+ G	H
Kanevskoy	28	36	22	8	0.8	0	G	F
Tbilissky	38	23	24	4	3	0	G	E
Giaginsky	36	31	39	2	1,5	4	G	H

* Degree of affection is a number of broomrape specimens per affected sunflower plant

The stereomicroscopic study of the early stages of tubercle and shoot development of race G, when susceptible sunflower genotypes are infected, showed that the stage of thickening of the host plant root in the haustorial area of the parasite, described previously (Antonova et al., 2022), is consistently observed with a fairly high frequency when evaluating the resistance of breeding material on an infectious background developed from broomrape seeds of this race. We continue to observe thickenings (as well as their absence) of the haustorial area of the parasite in the roots of sunflower plants under developing tubercles (Fig. 1 a-i). Furthermore, a tubercle with a thickening underneath and a tubercle without a thickening can be found side by side on the same root of the host plant (Fig. 1 h, i). This proves that the stimulation of the formation of such a thickening is a property of some individuals *O. cumana*. In Fig. 1 h, the large tubercle on the left feeds simultaneously on two roots of the host plant and both haustorial areas are thickened (indicated by arrows). On the right side of this figure, there is no thickening under two other tubercles located on different roots.

Usually, numerous growth meristems are formed in the tubercle, under which there is a thickening of the host plant root, from which multiple shoots develop (Fig. 2 a, b, c, d). When they reach the soil surface, we observe bushy forms (Fig. 3 a, b) of individual broomrape plants, which have become a common phenomenon in sunflower sowings in fields infested with the seeds of broomrape race G. The habitus of an individual broomrape plant has noticeably changed from 1-2-stemmed to multi-stemmed, although both forms will coexist in sunflower sowings for a long time.

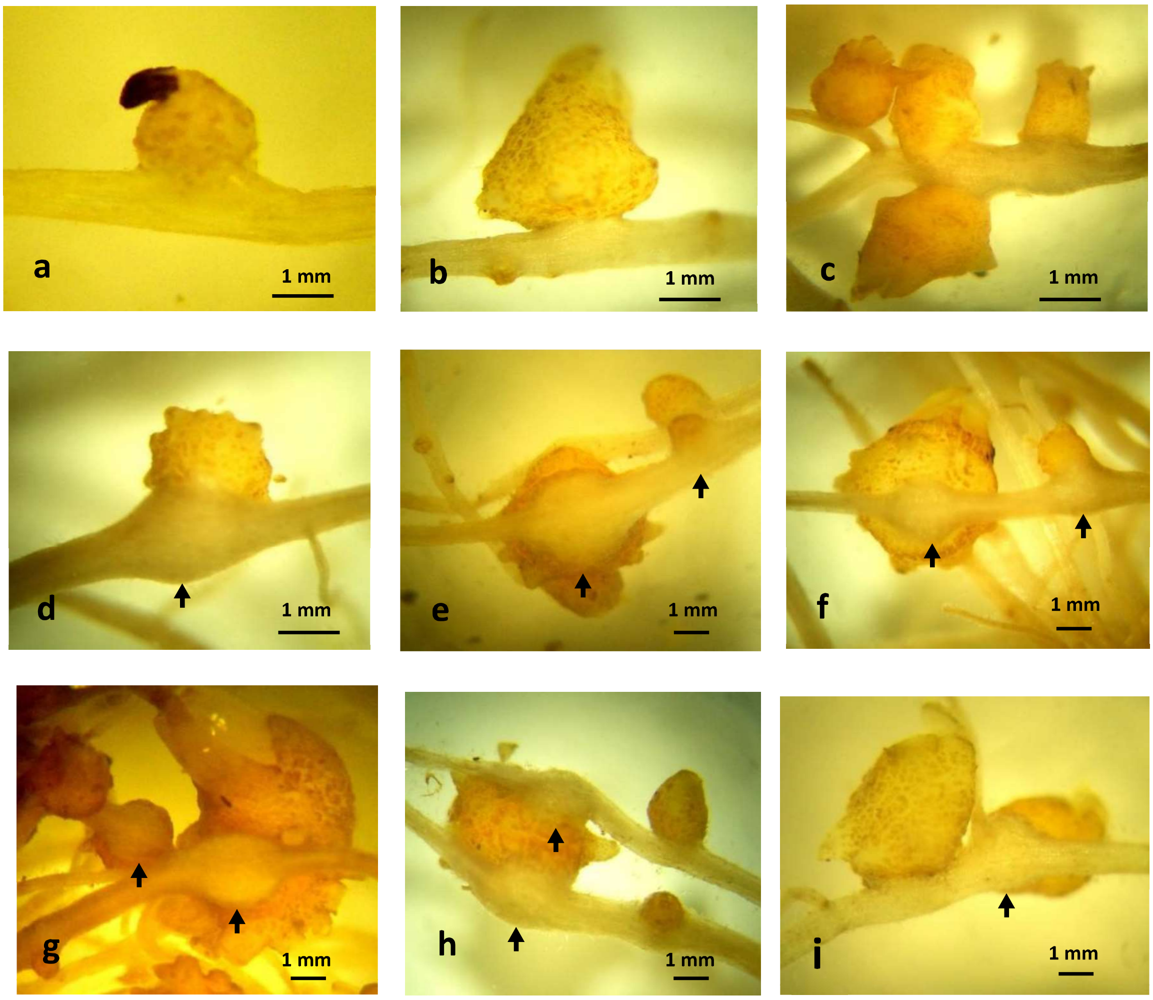

Fig. 1 a-i. The area of connection of the broomrape tubercle with the sunflower root: **a, b, c** - absence of root thickening under the tubercles; **d, e, f, g** - presence of thickenings (indicated by arrows); **h, i** - tubercles next to each other on the same root without thickenings under them and with thickenings (indicated by arrow); **h** - a large tubercle (left) has haustorial areas in two roots of the host plant and both are thickened (indicated by arrows). On the right, there are no thickenings under two other tubercles on different roots.

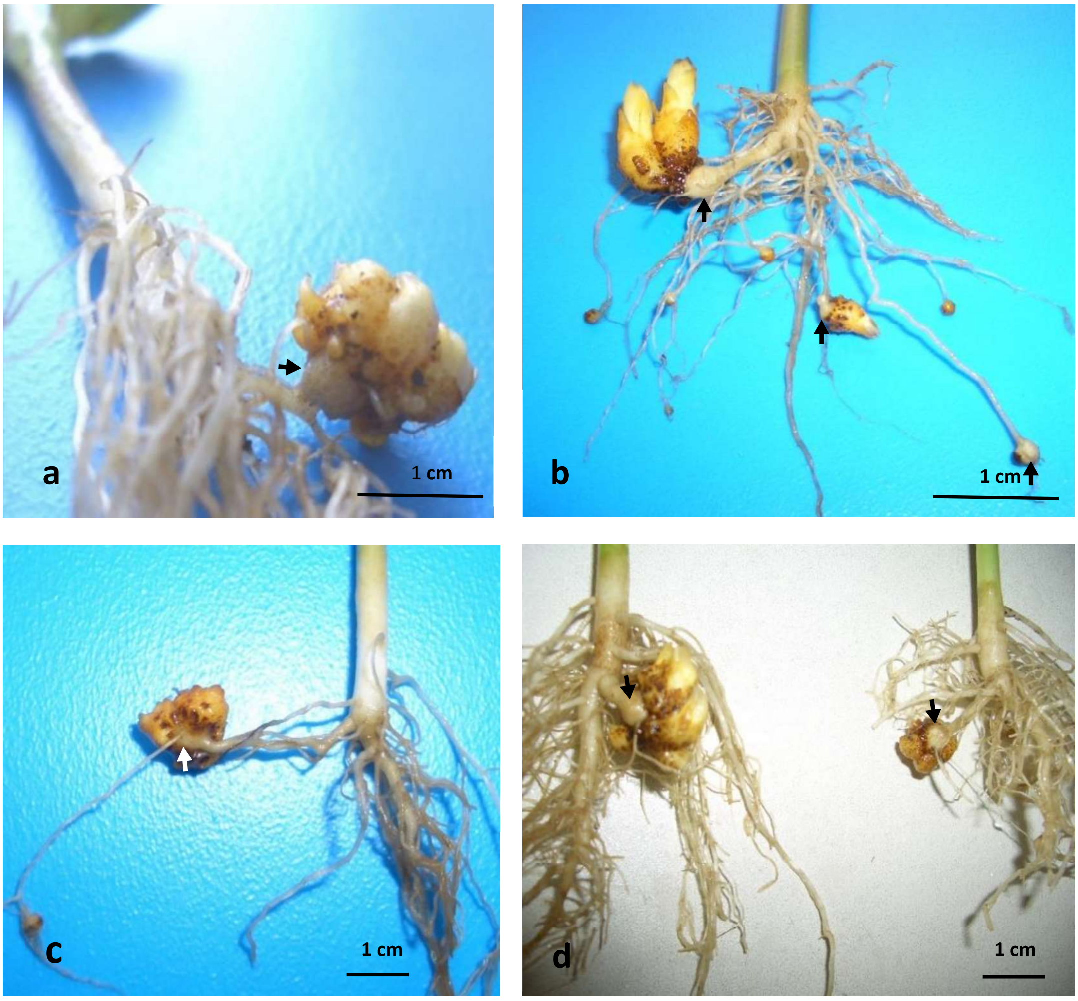

Fig. 2 a-d. Multiple shoots developing from *Orobanche cumana* tuber with thickening of the sunflower root underneath (**a, c, d**); **b** - thickening of the root under broomrape shoots and tubercles that are just beginning to develop.

We have also observed a phenomenon where the tubercle as such is partially or completely absorbed by the overgrown thickening of the haustorial area in the sunflower root, when its lower part is hidden by the root tissues. In this case, multiple shoots usually develop from the tubercle (Fig. 4 a, b). This suggests that, in the future the tubercles of *Orobanche cumana* will be immersed in sunflower root tissues in a gradual transformation process. From the point of view of the advantage of this location of the tubercle in relation to the external one for the broomrape specimen, parasitizing on sunflower, it is an evolutionary more advanced trait - the tubercle is protected from mechanical damage when inter-row weeding is carried out. Actually, the tubercle, as a basic stage of the formation of the future stem of the parasite, fulfils the function of accumulating in its cells the nutrients necessary for the formation and development of the apical meristem (one or more) and the beginning of shoot growth. It does not need to be outside the root of the host plant to perform this function.

Fig. 3 a, b. Bushiness is a new habitus found in plants of race G of *Orobanche cumana* on sunflower: **a** - mature bush; **b** - flowering bushes of some individuals (indicated by arrows) on the same host plant.

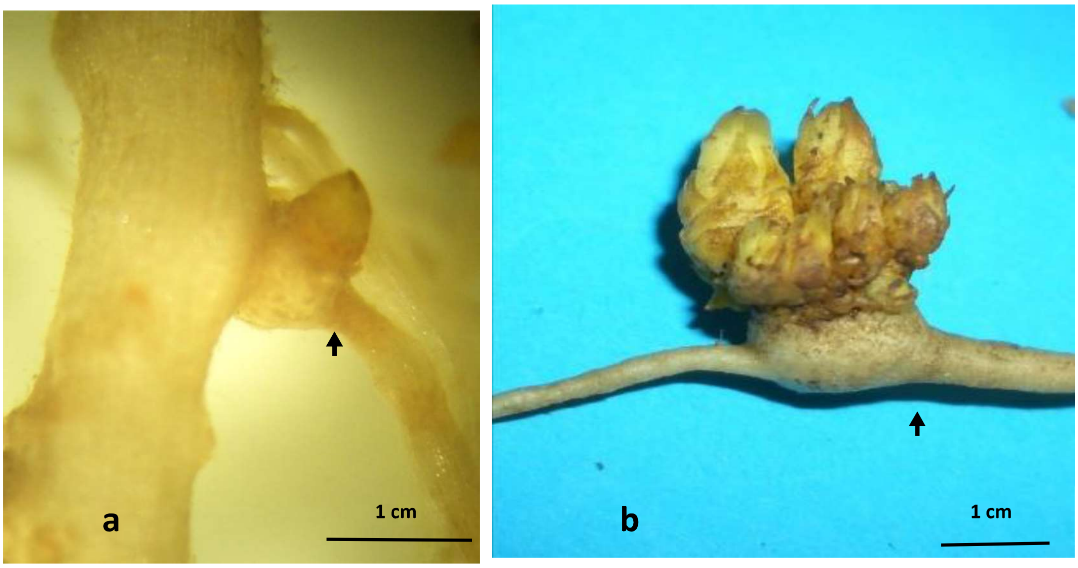

Fig. 4 a, b. Thickenings (indicated by arrows) of the haustorial area in the sunflower root, hiding the broomrape tubercle: **a** – complete absorption of the tubercle, the broomrape shoot that has started to develop emerges directly from the thickening in the sinus of the additional root; **b** - partial absorption of the tubercle, its lower part is hidden by the root tissue, and strong multiple shoots develop from its upper part.

The growth of the parasite's storage tissues and their filling with nutrients inside the sunflower root can ensure the initial development of a larger number of shoots, stems and, eventually, the production of a larger number of seeds in one broomrape specimen. It is possible that the strengthening of the whole structure, which we have called the thickening of the sunflower root in the haustorial area of the parasite, is facilitated by the accelerated formation of secondary tissues in the developing root of the host plant. It is also possible that broomrape has learned to stimulate the accelerated formation of secondary tissues in the root of host plant to protect and strengthen its own cells and tissues in the haustorial-tubercle area. This issue needs to be studied more closely. It is necessary to make an anatomo-histochemical study of such thickenings and to differentiate between parasite and host tissues within them. This should be the subject of further research.

CONCLUSIONS

Broomrape race G is dominant in the sunflower growing regions of the Russian Federation. However, the identification of the racial origin of broomrape seeds from different fields in six regions in the period 2020-2022 showed that there are fields with only races E or F or an equal (unequal) mixture of biotypes E, F, G. Half of the surveyed fields also contain seeds of the most virulent biotype H, which is not yet widespread enough to be called a new race.

It is shown that there are two types of specimens in populations of race G of *O. cumana*: a) - with thickening of the sunflower root in the haustorial area of the parasite and b) - without thickening. Forms with absorption of the tubercle by such a thickening, when the sunflower root tissue hides the tubercle, were revealed. It is shown that parasite specimens that stimulate the development of sunflower root thickening under the forming tubercle usually develop multiple shoots from it, which further form a bush on the soil surface. The bushy habitus characterizes a new morphotype of *O. cumana* specimens, which differs from the typical 1-2 stem form. Both morphotypes of *O. cumana* are present in the fields of the studied regions of the Russian Federation, which are infested with seeds of broomrape race G. The haustorial area of a broomrape specimen in the sunflower root plays a crucial role in the success of its parasitic lifestyle. Therefore, it is important to carry out an anatomo-histochemical study of the described thickenings of the haustorial area in the sunflower root under the tubercle of the parasite.

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ADVANCING BIOCONTROL STRATEGIES FOR BROOMRAPE MANAGEMENT

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ABSTRACT

Broomrapes are invasive, troublesome, and plant-parasitic weeds considered highly challenging to manage in the Mediterranean, including Türkiye. Their biological capabilities favor broomrapes to establish a parasitic relationship with their hosts and enormous seed bank and distribution. Therefore, conventional weed management strategies are inefficient to prevent, suppress, and control broomrape infestations. Broomrape management strategies should be purposefully designed, such as reducing or even inhibiting the seed bank, the ability to detect host plants, germination rates, and the capability to penetrate the host vascular system. Biological control of broomrapes has focused on insect herbivores, but the majority are not found to be broomrape-specific predators except Phytomyza orobanchia, which is reported to be a broomrape-specific biocontrol agent. However, the efficacy of P. orobanchia in reducing broomrape populations is quite limited by cultural practices. On the other hand, some bacteria, such as Pseudomonas aeruginosa, P. fluorescens, Bacillus atrophaeus, and B. subtilis, are reported to target the growth of broomrape radicles. Moreover, *Fusarium oxysporum f. sp. orthoceras, F. arthrosporioides, F. solani, Macrophomina phaseolina, Alternaria alternata,* and *Rhizoctonia solani* were isolated from the diseased inflorescences of Egyptian broomrape and were found to be pathogenic to the broomrape. Azospirillum brasilense could even inhibit the broomrape radicle growth. Moreover, mycorrhizal fungi populations such as Rhizobium leguminosarum or Azospirillum brasilense may mislead some broomrape seeds to find crop roots. Nevertheless, none of these biocontrol agents might disperse uniformly across the desired agricultural land, nor their broadcast application is easy. The scientific gap among these management strategies essentially requires further research.

Key words: Broomrape, Management strategies, Biological control

MONITORING OF *OROBANCHE CUMANA* WALLR RACES IN SUNFLOWER FIELDS OF NORTH EAST GREECE

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ABSTRACT

Weeds and especially the holoparasite *Orobanche cumana (*broomrape) are a serious problem in sunflower crop in Greece and worldwide, while the use of herbicide-resistant hybrids (HRC) dominates as a production system offering a valuable solution to the problem. The objectives of this work were, a) to assess the spatio-temporal spread of broomrape and the most important weeds in the main sunflower cultivation zone in Evros (NE Greece) and b) to evaluate the effectiveness of the new sunflower production system through the technologies Clearfield®, Clearfield® Plus, and ExpressSun®. Surveys were conducted in August 2022 in 71 fields in the aforementioned crop zone in order to, a) record the degree of broomrape infestation and the emergence of new noxious weeds, b) determine the effectiveness of the three applied technologies, and c) derive information on the farming practices followed by the farmers based on a questionnaire. The results were compared with those of surveys carried out in 2012 and 2015 where the abundance of broomrape and major weeds had been recorded in the same crop zone. The weed flora was recorded using sampling frames of 1m2, in a W pattern routes inside the fields and the population density of each species was estimated using the visual estimation according to Braun Blanquet methodology. The Abundance Index of broomrape and other important weeds was calculated and the data were saved in a geodatabase along with the data of farming practices and the use of applied herbicides. The spatial distribution of broomrape and important weeds in sunflower crop was mapped based on GIS as well as the prediction of their potential emergence in the surveyed zone. According to the records during 2022 survey, the species *Chenopodium album*, *O. cumana*, *Convolvulus arvensis*, *Echinochloa crus-galli*, *Xanthium strumarium* and *Cannabis sativa* were recorded in higher abundance. The applied technologies Clearfield® Plus, and ExpressSun® proved to be effective in broomrape control, while special attention needs to be paid to the use by the producers of the recommended hybrids by each technology and the correct application of herbicides. Importantly, a significant change in the weed flora was detected during the three reporting years of the surveys.

Key words: Broomrape, weeds, sunflower, spatio temporal dispersal, GIS

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DETERMINING THE YIELD PERFORMANCES AND THE RESISTANCE TO BROOMRAPE AND DOWNY MILDEW OF IMI TYPE SUNFLOWER (*HELIANTHUS ANNUUS* L.) HYBRIDS IN DIFFERENT LOCATIONS

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ABSTRACT

Sunflower (*Helianthus annus* L.) is the most grown oil plant due to its suitability to agricultural mechanisation and it is the most preferred vegetable oil for consumers in Turkey. One of the main challenging factors in sunflower cultivation is broomrape (*Orobanche cumana*) and downy mildew (*Plasmopara halstedii*). Additionally, some weeds such as *Xanthium strumarium* L. and *Cirsium arvense* also cause a problem. Sunflower hybrids which are resistant to imazamox (IMI) herbicides, play an important role to tackle broomrape and the other weeds. In this study, the yield performances of the hybrids, which are resistant to IMI herbicides and are developed within the scope of TARI's National Sunflower Project, have been investigated in different locations (Vakıflar, Ahmetbey and Edirne) in 2022. The resistance of the varieties to broomrape and downy mildew were evaluated under the natural conditions and also through the artificial inoculation. The experimental design was a Randomized Complete Block Design with four replicates. The four rows plots were 7,50-m long with the 70 x 30 cm plant spacing. 4 commercial hybrids, which are widely cultivated in Turkey, took place as checking varieties. Weed control was with IMI herbicide (Imazamox (40 g/l) with 1.25 l / ha dose after 6-8 leaf stage. Statistical analysis was performed with JMP statistical program. As a result, some varieties of the experiments have shown high resistance to broomrape and downy mildew under the field conditions. The results of artificial inoculation tests display that there were a number of varieties determined as highly resistant to broomrape and downy mildew. Some of the selected varieties are promising and are ready to be nominated for the registration in Turkey.

Keywords: Sunflower, broomrape, downy mildew, breeding for resistance, IMI herbicides, hybrid breeding

UPDATE ON SUNFLOWER BROOMRAPE SITUATION IN SPAIN

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ABSTRACT

Sunflower broomrape (*Orobanche cumana* Wallr.) is an allochthonous parasitic plant species in Spain, where it only occurs in sunflower crops. It was introduced in the 1950s in central Spain and in the 1970s in southern Spain. Recent studies suggested that they were two separate introductions, probably from different geographic areas. Both gene pools evolved from race E to race F in the 1990s, presumably by point mutations since no increase in genetic diversity was detected. The racial situation of the parasite in both race-F gene pools, named Guadalquivir Valley (FGV) and Cuenca (FCU), was stable until recently, when more virulent populations were detected in both. Our studies suggested that the increased virulence in the GV was caused by the genetic recombination of avirulence alleles of both gene pools FGV and FCU, resulting in a new race named GGV that parasitizes race-F resistant hybrids carrying Or7 allele but not DEB2 line, with Ordeb2 gene that provides resistance to race-G populations from eastern Europe. In central Spain, a recent study has revealed that populations from the GV (FGV and/or GGV) have been introduced in the area at a large scale, with genetic recombination between CU and GV populations that will probably result in an expansion of the GGV race in this area. Additionally, we have detected a new race in CU characterized by parasitization on DEB2 but not on hybrids carrying Or7. This new race, named FCU+, did not result from the introgression of any external avirulence gene since no increased intrapopulation diversity was detected. Accordingly, it is hypothesized that a point mutation caused it. The increasing complexity of the sunflower broomrape situation in Spain urges control measures aimed at curtailing its expansion into new regions, together with the identification of novel sources of resistance to ensure the sustainability of this crop, currently essential for Spanish agriculture.

Keywords: Sunflower broomrape, parasite, wild species, resistance

BROOMRAPE RESISTANCE FROM WILD SPECIES

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ABSTRACT

Sustaining sunflower production necessitates the comprehensive management of pests and diseases, primarily focusing on bolstering the crop's genetic resistance. Sunflower broomrape (*Orobanche cumana* Wallr.) poses a significant challenge in this regard, as its rapid evolution of virulence hinders traditional breeding efforts for resistance. Presently, all known resistance genes have succumbed to more virulent parasite strains, prompting renewed endeavors to discover novel sources and mechanisms of resistance. Wild species of Helianthus currently emerge as the primary reservoirs of untapped resistance genes. In this presentation, we will explore the strategies being developed by research groups worldwide to identify and characterize fresh resistance genes against sunflower broomrape and to incorporate them into cultivated sunflower varieties.

Keywords: Sunflower broomrape, parasite, wild species, resistance

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