

**T.C.
AKDENİZ UNIVERSITY**



**INVESTIGATION OF SOURCES OF EGGPLANT (*SOLANUM MELONGENA*)
RESISTANT TO *LYGUS* SEVERAL SPECIES**

Şükrü YILDIRIM

**INSTITUTE OF SCIENCE
AGRICULTURAL BIOTECHNOLOGY
DEPARTMENT
MASTER THESIS**

FEBRUARY 2020

ANTALYA

**T.C.
AKDENİZ UNIVERSITY**



**INVESTIGATION OF SOURCES OF EGGPLANT (*SOLANUM MELONGENA*)
RESISTANT TO *LYGUS* SEVERAL SPECIES**

Şükrü YILDIRIM

**INSTITUTE OF SCIENCE
AGRICULTURAL BIOTECHNOLOGY
DEPARTMENT
MASTER THESIS**

FEBRUARY 2020

ANTALYA

T.C.
AKDENİZ UNIVERSITY
INSTITUTE OF SCIENCE

**INVESTIGATION OF SOURCES OF EGGPLANT (*SOLANUM MELONGENA*)
RESISTANT TO *LYGUS* SEVERAL SPECIES**

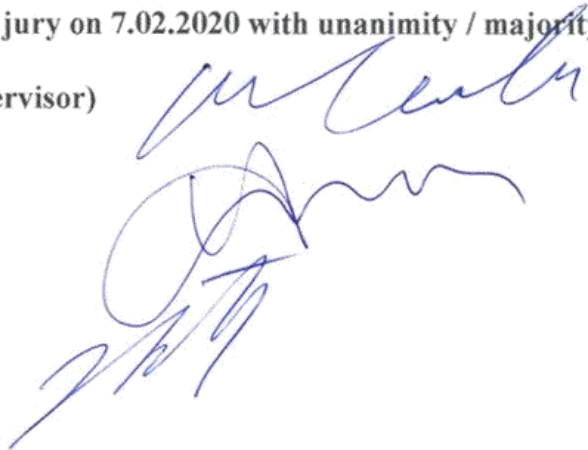
Şükrü YILDIRIM
INSTITUTE OF SCIENCE
DEPARTMENT
MASTER THESIS

This thesis was accepted by the jury on 7.02.2020 with unanimity / majority vote.

Prof. Dr. Nedim MUTLU (Supervisor)

Assoc. Prof. Dr. Hasan PINAR

Asst. Prof. Hatice İKTEN



ABSTRACT

INVESTIGATION OF SOURCES OF EGGPLANT (*SOLANUM MELONGENA*) RESISTANT TO *LYGUS* SEVERAL SPECIES

Şükrü YILDIRIM

MSc Thesis

Department of Agricultural Biotechnology

Supervisor: Prof. Dr. Nedim MUTLU

February 2020; 32 pages

Eggplant, an important species of Solanaceae family, is rich for vitamins and minerals with a vegetable of great economic value. In Turkey, eggplant is produced both in open fields and greenhouses, and there are many problems that limit production and quality of eggplants. *Lygus* spp. is one of the emerging pest problems. *Lygus* is generally known as a cotton pest. But in recent years, open-field eggplant tests particularly in Korkuteli-Antalya, showed potentially economic damage of the pest on eggplant production. This problem has increased in open-field eggplant cultivation in recent years. To date, a line resistant to *Lygus* spp has not been reported. The objective of the study was to identify resistant sources of this pest in eggplant through field test. A replicated field trial involving, seven different varieties of eggplant, 250 different plants have been studied and observed in Korkuteli-Antalya region (2019). The eggplant genotypes were scored for resistance against *Lygus* damage. In the observations, especially meristem and flower damage were taken into account. *Lygus* damage to orobanche (*Orobancha spp.*) and potato beetle (*Leptinotarsa decemlineata*) have also been identified and measured. The data related to the findings obtained in this study was used in excel for statistical analysis. In this study, all forms of damage from *Lygus* spp. it is understood that eggplant's major damage was on the stem of the flowers. For this purpose, meristem and stalk observation method were used to test eggplant plants. And two genotypes with potential resistance against *Lygus* were identified. These sources are both *S.macrocarpon*, MM1127 and MM12209 materials, and they showed more than 60% resistance in both materials.

KEYWORDS: Antalya, Eggplant, *Lygus* spp., Resistance

COMMITTEE: Prof. Dr. Nedim MUTLU

Assoc. Prof. Dr. Hasan PINAR

Asst. Prof. Dr. Hatice İKTEN

ÖZET

LYGUS SPP.'YE KARŞI DAYANIKLI PATLİCAN (*SOLANUM MELONGENA*) KAYNAKLARININ ARAŞTIRILMASI

Şükrü YILDIRIM

Yüksek Lisans Tezi

Tarımsal Biyoteknoloji Anabilim Dalı

Danışman: Prof. Dr. Nedim MUTLU

Şubat 2020; 32 sayfa

Patlıcan *Solanaceae* familyasında bulunan, vitamin ve mineral içeriği bakımından diğer sebzeler kadar değerli olup ülkemiz dahil pek çok ülkede büyük ekonomik değere sahip bir sebze türüdür. Ülkemizde patlıcan yetiştiriciliği hem açık tarlada hem serada yapılmakta ve üretimi kısıtlayan birçok sorunla karşılaşmaktadır. *Lygus spp.* Patlıcan üretimini etkileyen sorunlardan biridir. *Lygus* genel olarak bir pamuk zararlısı olarak bilinir, ancak son yıllarda yaptığımız açık arazi patlıcan denemelerinde özellikle Korkuteli-Antalya'da bu zararlıyla karşılaşmıştır. *Lygus spp.*'ye karşı dayanıklı hat geliştirmek için günümüze kadar ki yapılan çalışmalarda, pamuk ve fasulye bitkileri üzerine çalışılmış ve patlıcanla ilgili herhangi bir çalışmaya rastlanmamıştır. Son yıllarda açık alan patlıcan yetiştiriciliğinde bu problem ciddi artış göstermiştir. Bu çalışmada patlıcanda bu zararlıya karşı dayanıklı kaynak bulmak hedeflenmiştir. Bu tez çalışması bu *Lygus* türlerinin patlıcan bitkisindeki zararının araştırılması varsa dayanıklılığın tespitini kapsamaktadır. Yedi farklı patlıcan çeşiti 250 farklı bitki Korkuteli-Antalya bölgesinde (2019) incelenip gözlemlenmiştir. Gözlemlerde özellikle meristem ve çiçek zararı dikkate alınmıştır. Aynı zamanda arazide bulunan diğer zararlılarda gözlemlenmiştir. Canavar otu ve patates böceği zararları da gözlemlenmiş ve değerlendirilmiştir. Bu çalışmada *Lygus spp.*'nin yaptığı tüm zarar şekilleri incelenmiştir. Bu çalışmada elde edilen bulgulara ait veriler istatistik analizler için excel kullanılmıştır. Patlıcan için asıl zararı ise çiçek sapına yaptığı bilinmektedir. Bu sebeple patlıcan bitkileri meristem ve çiçek sapı gözleme metodu ile değerlendirilmiştir. Sonuç olarak iki farklı dayanıklı kaynak tespit edilmiştir. Bu kaynakların ikisinde *S.macrocarpon* olup MM1127 ve MM12209 materyalleri olup iki materyalde %60'ın üzerinde dayanım göstermiştir.

ANAHTAR KELİMELEER: Antalya, Dayanıklılık, *Lygus spp.*, Patlıcan

JÜRİ: Prof. Dr. Nedim MUTLU

Doç. Dr. Hasan PINAR

Dr. Öğr. Üyesi Hatice İKTEN

PREFACE

In the thesis study, damage patterns caused by *Lygus* spp species were investigated and resistant eggplant genotypes were identified. As a result of the trials, two genotypes were determined to be resistant to this insect.

I would like to thank my supervisor Prof. Dr. Nedim MUTLU who shared his knowledge and experience with me in my work and always supported me.

I would like to thank Rijk Zwaan Seed Company that provided material support for my project, my Phytopathology team mates who I had the opportunity to work with in the field, my friend Pelin SARIKAYA who helped me in writing the thesis, my mother Gülten YILDIRIM and my father Rahmi YILDIRIM for all their sacrifices.



CONTENTS

ABSTRACT.....	i
ÖZET.....	ii
PREFACE	iii
TEXT OF THE OATH.....	v
SYMBOLS and ABBREVIATIONS	vi
LIST OF FIGURES	vii
LIST OF TABLES	viii
1. INTRODUCTION	1
2. LITERATURE REVIEW.....	5
2.1. Definition, Origin, Cultivation and Domestication of Eggplant	5
2.1.1. Economic Significance	6
2.2. General Informations About <i>Lygus spp.</i>	7
2.2.1. Description, Life cycle and Damage Type	8
2.3. Mechanism of insect resistance:.....	8
2.3.1. Antibiosis.....	9
2.3.2. Antixenosis	10
2.3.3. Tolerance/Recovery	10
3. MATERIAL AND METHOD	11
3.1. Plant Material	11
3.1.1. Experimental Region	11
3.2. Method.....	12
3.2.1. Observation method.....	13
4. RESULTS	14
5. DISCUSSION	23
6. CONCLUSION	28
7. REFERENCES.....	29
RESUME	

TEXT OF THE OATH

I state that this study titled “Investigation of Sources of Eggplant (*Solanum Melongena*) Resistant to Lygus Several Species”, which I submitted as a Master Thesis, was written in accordance with academic rules and ethical values, and I declare that I showed the source of all information that is not mine.

07/02/2020

Şükrü Yıldırım



SYMBOLS and ABBREVIATIONS

Symbols

cM	:	Centimorgan
mm	:	Millimeter
Kb	:	Kilobase
g	:	Gram
hr	:	Hour
°C	:	Celsius temperature
%	:	Percent
mg/kg	:	Milligram per kilogram

Abbreviations

AU	:	Akdeniz University
CTAB	:	Cetyl Trimethyl Ammonium Bromide
DNA	:	Deoksiribo Nükleik Asit
FAO	:	Food and Agriculture Organization
MAS	:	Marker Assisted Selection
PCR	:	Polymerase Chain Reaction
spp	:	Severel species
TÜİK	:	Türkiye İstatistik Kurumu

LIST OF FIGURES

Figure 1. 1 Eggplant with egg-like shape and color (Anonymus 1)	1
Figure 1. 2 Some different fruit shapes, colors and sizes in the World Vegetable Center collection (Taher 2017).	3
Figure 2. 1 Eggplant species used in the study.....	6
Figure 3. 1. Region that we carried out this study.....	11
Figure 3. 2. Pictures of Melongena, Macrocarpon, Tomentosum, Anguivi, Incanum, Rubetorum, Linnaeanum.....	12
Figure 3. 3 A: Picture of <i>Lygus lineolaris</i> ; B: Picture of <i>Lygus hesperus</i>	12
Figure 4. 1. Flower damage caused by <i>Lygus</i> spp.....	14
Figure 4. 2. Scores of resistant materials	14
Figure 4. 3. Flower damage.....	16

LIST OF TABLES

Table 3. 1. Eggplant species used in this study	11
Table 3. 2. Lygus in eggplant test	13
Table 3. 3. Observations timeline.....	13
Table 4. 1. Average of flower total scores.....	15
Table 4. 2. Correlation between two flower scores	16
Table 4. 3. Average of flower total score (16&17.07.2019)	17
Table 4. 4. Average of Meristem.....	17
Table 4. 5. Correlation meristem damage two score dates.....	19
Table 4. 6. Correlation average meristem and flower	19
Table 4. 7. Correlation greenhouse and field meristem score	20
Table 4. 8. Correlation greenhouse meristem (LYR11) and field flower score (July 2019)	21
Table 4. 9. Correlation meristem damage by Lygus and number of fruits in August	21
Table 4. 10. Correlation flower and fruit.....	22
Table 5. 1. Average of leaf damage mainly caused by damage from probably <i>Spodoptera exigua</i>	24
Table 5. 2. Average of Colorado beetle damage density for Lygus field test	25
Table 5. 3. Avarage of Orobanche density for Lygus field test	26
Table 5. 4. Correlation Lygus and Colorado beetle.....	27

1. INTRODUCTION

Solanaceae (Eggplant) family includes 90 genera and approximately 2,500 species in tropical and subtropical regions (Vorontsova and Knapp 2012). More than 300 *Solanum* species are found in the Old World (Africa and Eurasia) and Australia (Levin et al. 2006; Vorontsova and Knapp 2016). In Turkey, 12 genera and 36 species are known. *Solanum* genus of *Solanaceae* family contains 107 species. The basic chromosome number of most taxa of the genus *Solanum* is $n = 12$ (Chiarini et al. 2010). Eggplant (*Solanum melongena*) is a vegetable species of the *Solanum* genus of the *Solanaceae* family.

Eggplant (*Solanum melongena*) is known as aubergine or eggplant and is an economically important vegetable in many countries. According to Candolle (1883), it was known in ancient times in India and its first registration in Europe was made in the 15th century. It is called plant eggplant because its fruit shape and color resemble eggs (Sao and Metha 2010).



Figure 1. 1 Eggplant with egg-like shape and color (Anonymus 1)

Eggplant (*Solanum melongena* L.) is the third most economically important crop (Rotino et al. 2005). Eggplant is one of the most widely grown fruit and vegetable products in the world with a harvest area of 1858253 hectares, producing more than 50 million tons worldwide. (FAOS, 2019)

The production area is mainly within the subtropical zone for both greenhouse and open space, more than 90% of the world's production area is concentrated in Asia, followed by Africa, the Mediterranean Basin and South America (Mutlu and Boyacı 2008).

In European countries, eggplant is an exotic crop, but in Asia and the Mediterranean it is an important and valuable nutritional feature, the so-called 'King of Vegetables' (Şekara et al. 2007).

Solanum melongena, *P. insanum* and *Solanum incanum* (Daunay et al. 1991) has been described as “Eggplant complex” by Pearce and Lester (1979). However, the most commonly used varieties of eggplant are three closely related species: *S. melongena* L., *S. aethiopicum* L. and *S. macrocarpon* L. that are commonly the most famous species (Daunay et al. 2001) and is cultivated worldwide.

The most important eggplant producing countries are; China (32 million tons), India (12.5 million tons), Egypt (1.2 million tons), Turkey (0.85 million tons) and Iran (0.67 million tonnes). Eggplant is among the five most important herbal products (tomato, pepper, potato, tobacco, eggplant) in Asia and the Mediterranean (FAO 2016).

Eggplant is one of the oldest vegetable species cultivated to meet the human food needs. Eggplant is a vegetable that is easily cooked in all kinds of dishes, judged as a side dish, salad, jam and pickle. It is known that eggplant's place in human health is not to be underestimated by other types of vegetables. Eggplant is considered among the healthiest vegetables in terms of its high vitamin, mineral and bioactive compound content for human health (Raigón et al. 2008; Plazas et al. 2014; Docimo et al. 2016).

The calorie value of 100 grams of eggplant is 24 and contains 1.1 g of protein, 2 g of fat and 5.5 g of carbohydrates. In terms of Vitamin content, there are 30 IU of vitamin A, 0,4 mg of Vitamin B1, 0,5 mg of vitamin B2 and 5 mg of vitamin C in 100 grams (Anonim1). Both phenolic acids and anthocyanins found in eggplant have many properties beneficial to human health (Plazas et al. 2013; Braga et al. 2016).

The most common assumption for eggplant's homeland is India, but China's equally ancient eggplant records have been found. Both regions have a high proportion of wild eggplant populations. *Solanum melongena*'s *Solanum incanum* L. and the origin of the species *Solanum undatum* Lam has been tried to be understood by various analyses. it has been shown that one of melongena's two not-so-genetically distinct ancestors may be in India and the other in China (Knapp et al. 2013).

In the WorldVeg database system, it is possible to find that between the 1,308 entries of *S. melongena*, green and purple fruits are 38-47%, while eggplant genotypes are slightly longer and wider than normal fruits, with 31.1% and 18.7% respectively. The 98 records of *S. melongena* and *S. aethiopicum* have been found to be large, and there is a weak correlation between *S. macrocarpon* fruit quality descriptors for different fruit characteristics such as plant height, flowering time, fruit lenght and acidity (Polignano et al. 2010). In terms of fruit taste, it was reported that 26.8% was sweet, 53.2% was slightly sweet and 6.1% was bitter. In a study conducted by AVRDC (1996), dry matter ratio, total sugar content and fiber contents were found to be large among 90 eggplant genotypes. The distribution of dry matter, total sugar and fiber content ranged from 5.5 to 10.1, 7.0 to 40.1 and 4.7 to 18.1 percent, respectively.



Figure 1. 2 Some different fruit shapes, colors and sizes in the World Vegetable Center collection (Taher 2017).

Because Turkey has different climatic and soil conditions, many different types of vegetables can be produced. However, eggplant is a vegetable that is not preferred easily by every producer due to the climate and soil requirements and the difficult maintenance conditions. According to TUIK data (2018), 836,284 tons of eggplants were produced in 199,292 da area in Turkey. The Mediterranean region is the region with the highest eggplant production with 431.506 tons in 69.191 da area. The 190.125 tons of production was made in 23.560 da area in Antalya province in Mediterranean region. Antalya province alone gets 20% share of the eggplant in Turkey (TUIK 2018).

Eggplant production conditions in Turkey can be made both in the open and under cover. The most important provinces with eggplant production in Turkey; Antalya, Mersin, Adana, Sanliurfa, Hatay, Aydın, Bursa and Samsun (Akan and Demir 2012).

Vegetation starts in the fall in the Mediterranean area for protected areas such as greenhouse vegetables grown under glass or plastic greenhouses and continues until the beginning of summer. In the Mediterranean region, tomatoes, peppers, cucumbers and eggplants are the most common vegetables in greenhouse cultivation. Eggplant production in different periods, there are many biotic and abiotic factors that are harmful to varying degrees in eggplant. Abiotic factors are wind, storm, snow, hail, frost, high and low temperatures, inundation and nutrient deficiency. Biotic factors are viruses, bacteria, fungi, nematodes, insect pests and mites.

Farmers need improved eggplant varieties to adapt to the challenges of sustainable production and climate change. Because eggplant has a relatively long growth period, it is more exposed to a wide variety of diseases, pests, nematodes and weeds compared to other plants. Among the most common diseases are bacterial wilt, *Verticillium* and *Fusarium* Wilts, anthracnose, fruit rot, *Alternaria* rot, *Phytophthora* blight, fruit rot, leaf spot, small leaf, mosaic leaf formation (Rotino et al. 1997). Unpredictable weather conditions such as extreme temperatures, droughts or floods can lower yields and fruit quality. In general, high-yield eggplant breeding programs are mainly aimed at developing hybrids, resistant to major disease and pest insects, high fruit quality, long shelf life and wide adaptation to environmental stress (Daunay and Hazra 2012). Eggplant is attacked by many harmful insects, including mites, whiteflies, aphids, caterpillars, spotted beetles, and leaf fleas (Rotino et al. 1997).

In Turkey, eggplant cultivation is done both in open fields and in greenhouse and many problems that restrict production are encountered and *Lygus* spp. is one of them. *Lygus* is generally known as a cotton pest, but we have encountered this pest in Korkuteli-Antalya in recent years, especially in open field eggplant trials. Damage is in the form of sucking at flower stems in the first stage of the flowers that caused bud-satge flower to drop while the vegetative part of the plant appears quite healthy, but no fruit formation occurs. The objective of the study was to test the selected 250 different resistant materials from the eggplant gene pool of Rijk Zwaan Seed Company against *Lygus* under open field conditions in a replicated field trial at Korkuteli, Antalya in 2019 growing season.

2. LITERATURE REVIEW

2.1. Definition, Origin, Cultivation and Domestication of Eggplant

Solanaceae (Eggplant) family contains 90 genera and 2500 species spread in tropical and subtropical regions. The 12 genera and 36 species are known in Turkey. *Solanum* genus of *Solanaceae* family contains 107 species. Cultivated eggplant belongs to *Solanum* genus of *Solanaceae* family. Its scientific name is *Solanum melongena*. Eggplant is an annual plant that grows in temperate climates and grows as a small tree in tropical climates. The first cultivation of eggplant was in India in the 5th century BC and brought to Europe in the 16th century by the Spaniards. Eggplant, used as an ornamental plant when it was first brought to Europe, ranks 6th among the fresh vegetables produced in the world. The only species that consumes eggplants is human because it contains low nicotine. It is a perennial plant in tropical regions. The name "eggplant" is probably related to the egg shape and white fruit of *Solanum melongena* species (Kalloo 1993).

Eggplant (*Solanum melongena* L.) belongs to the large *solanaceae* family (nightshade family), containing ~ 3,000 species scattered across 90 genera (Vorontsova and Knapp, 2012). The asterid dicot genus, divided into thirteen clans, is underneath the *Leptostemonum* kinship group, referred to as the "spiny *Solanum*" cluster because of the presence of sharp dermal tingles on eggplant, stems and leaves (Vorontsova et al.2016).

Solanum L. is one of the biggest genera with concerning 2300 species (Sekara et al. 2007). The quantity of species within the asterid dicot genus, to completely different sources (Sakata and Lester 1994, Isshiki et al 1994c, Lester 1997, Daunay et al 1998) potato (*Solanum tuberosum* L.) and tomato (*Solanum Lycopersicum* L.), and lots of alternative little product. Eggplant is the third economically necessary crop within the family *Solanaceae*, after potatoes and tomatoes.

The eggplant (*Solanum melongena* L.) is one of the few *solanaceous* species cultivated, according to the sciences; it probably originated from the Old World, especially India (Daunay, 2008).

In Turkey, eggplant has been fully grown since the start of the seventeenth century. The origin of eggplant is indirectly derived from the wild asterid dicot genus *incanum*, domesticated in India and Southeast of China. (Lester 1998). Eggplant encompasses three closely related cultivated species, endemic to the Old World, belonging to the genus *Solanum* L. subgenus *Leptostemonum*: *S. melongena*, *S. macrocarpon*, *S. incanum*, *S. linnaeanum*, *S. anguivi*, *S. rubetorum*, *S. tomentosum*.

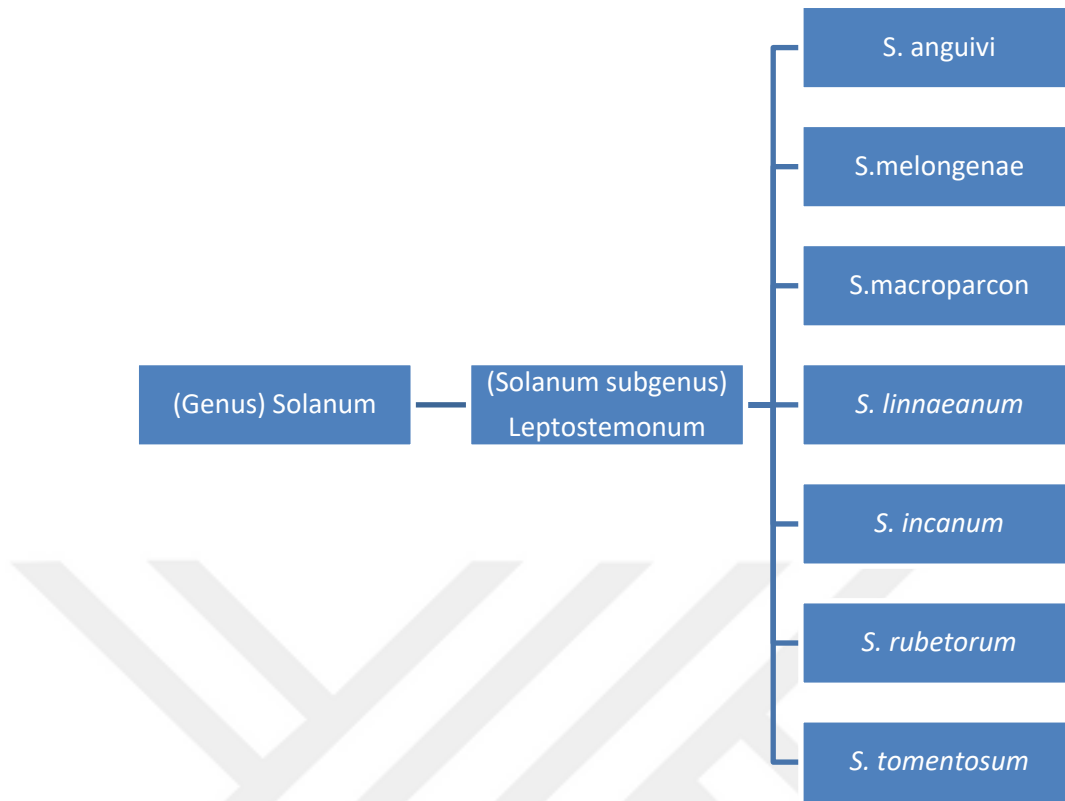


Figure 2. 1 Eggplant species used in the study

The basic chromosome number of eggplant is $n = 12$ (Chiarini et al. 2010) and $2n = 24$ (Şekara et al. 2007) is an autogamous diploid with genome size approximately 956 Mbp (Bennett and Leitch 2004).

The name “eggplant” comes from form|the form} and color of the vegetable’s fruit (Lester 1998) some egg-like shape varieties in USA and Canada, called “aubergine” in Europe, the name “brinjal” is common to geographical region, South Asia, and Africa. There also are alternative renowned names are melongen, garden egg, and guinea squash (Nothmann 1986, Choudhury 1995, Lawande and Chavan 1998, Daunay et al. 1999 and Kashyap et al. 2003).

2.1.1. Economic Significance

Eggplant is a very popular native vegetable in Asia and the Mediterranean region. China (17 million tons per year) and India (8 million tons) are the two countries with the primary cultivation centers and the highest production (FAOSTAT Data 2018). After the spread of Indian and Chinese culture to Japan, Today Japan is the major producer. The entrance to the West was mainly around the Mediterranean region, which was a secondary “domestication zone” and encompassed Turkey (0.8 million tons), Syria and Iran (Nothmann 1986, Daunay et al. 2001, Kashyap et al. 2003).

The average yields vary greatly depending on the environment, the cultural structure, the length of the crop and the cultivation technology. The Netherlands is the

number one country with an output of 390 tons per hectare (Doğanlar et al. 2002). Earlier, other Mediterranean nations, such as Italy, Spain, France and Greece, were producers of eggplant (Lawande and Chavan 1998, Daunay et al. 2001, Frary et al. 2007). Today, Turkey is ranked first in Europe in terms of total eggplant production (Economic Research Service, USDA 2017). There is a large difference in the yield of eggplant production due to the growing climate, technology and varieties. In general, eggplant is now a globally grown plant species (Daunay et al. 2001, Doğanlar et al. 2002). Eggplant is grown worldwide, world production in 2017 is about 52 million tons, China with 32 million tons and India with 12 million tons are the largest producers (FAOSTAT, 2017).

Top 10 Eggplant Producers

- 1) China, Mainland
- 2) India
- 3) Egypt
- 4) Turkey
- 5) Iran
- 6) Indonesia
- 7) Japan
- 8) Italy
- 9) Philipinnes
- 10) Spain

Eggplant is a winter spring vegetable in greenhouse and summer vegetable for outdoor field production and consumption in Turkey. Annual production in Turkey is approximately 900,000 tons. Eggplant is ranked fourth for greenhouse production. Tomatoes are in first place with 12 million, peppers are in second with 2.5 million and cucumbers are in 1.8 million production (TUIK, 2018).

2.2. General Informations About *Lygus spp.*

Tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois) (Heteroptera: Miridae), are pests of many fruits, vegetables, feed, seeds, ornamental and fiber plants in North America. Historically, Tarnished plant bugs management in cotton has been obtained secondary to the application of broad-spectrum insecticides targeting pests such as boll weevil (*Anthonomus grandis* (Boheman)), tobacco budworm (*Heliothis virescens* (F.)) and bollworm (*Heliothis zea* (Boddie)). However, the emergence and widespread cultivation of transgenic cotton varieties designed to kill many of these traditional cotton pests has led to a reduction in the use of broad-spectrum insecticides with the completion of Cocoon beetle eradication efforts in many areas (Musser et al. 2009). This blackened plant bug has allowed Mississippi, Louisiana, Arkansas, Tennessee and Missouri to become a more dominant pest than cotton in the last few years. In addition, plant insect resistance to existing insecticides is increasing (Snodgrass 1996, Hollingsworth et al. 1997, Snodgrass and Scott 2002, Snodgrass et al. 2009). A combination of all these factors elevated the key pest status of tarnished plant bugs in the mid-southern cotton growing regions. Tarnished plant bugs can damage cotton plants in various ways. Before flowering, tarnished plant bugs feed terminal shoots and buds, potentially causing deformations leading to loss of apical dominance (Hanny et al. 1977). They also feed on

small flower buds (squares), exhibiting dark anthers with no pollen, resulting in the bud / square abscission and older than the more advanced buds, resulting in “dirty blum”. Tarnished plant bugs feeding on the small Cocoon can cause an abortion where feeding on the larger Cocoon can cause stained hairless and damaged seeds (Pack and Tugwell 1976, Layton 2000)

2.2.1. Description, Life cycle and Damage Type

They absorb leaves, fresh sprouts, scallops, flowers and fresh cocoons to dry them and cause them to drop. Pale spots are formed due to toxic secretions in the suction areas. On the leaves, these spots spread between the tissue, become blackish brown, expand, and then the leaves, which take on a mosaic appearance, become curl and dry.

Other than cotton, they are harmful in eggplant, tomato, tobacco, cabbage and alfalfa. Adults are yellowish red or pale yellow in color. Their wings are wavy, their nymphs are yellow first, then green and pinkish. Body length of adults are 3-7 mm.

Morphological characters used to distinguish *Lygus* species include patterns in the scutellum and fron (face), the number of spots in the pronotum, the presence / absence of traces in the propler, the transparency of the wing membranes, and the relative length of the sphere (Schwartz and Footfit 1998, Mueller et al. 2003).

Lygus lineolaris is distinguished from, for example, *hesutus* and *L. elisus* by the presence of dark markings in the scutellum and fron. *Lygus hesperus* has several black spots (usually extending to rays) in the pronotum, while *L. elisus* has two such spots. *Lygus hesperus*'s props usually have one or two lines or stains, while none of *L. elisus*. The wing membrane on *L. elisus* is sharper than that of *L. hesperus*. On the ventral side, the rostrum of *L. hesperus* usually extends below the attachment point of the last leg pair, while the rostrum of *L. elisus* is shorter (Antwi and Rondon 2018).

More than 30 years ago, Strong (1970) suggested that the damage caused by *Lygus* insect feeding in alfalfa, cotton and other crops was primarily biochemical rather than mechanical, and mainly caused by the insect's salivary PG (polygalacturonase). These hypotheses have been tested using a glass micro-capillary to introduce small volume solutions to certain areas of alfalfa and cotton flower tissues and have been found to cause mechanical damage possibly caused by insect feeding. The introduction of a significant enzyme sequence containing a small amount of protein (usually <1 µg per injection) into *Lygus* HPE (head-pronotum extract) has shown that clover and cotton.

2.3. Mechanism of insect resistance:

As a result of the widespread and unconscious use of pesticides, 5 types of genetic resistance are emerging: pest, special, behavioral, structural, physiological and cross-resistance. In all the resistance types given below, why are the new genetic gains of mutation origin. Special resistance is the resistance that arises due to the individual property of the pest. For example, while one of the two insects in the same family of the same team is sensitive to one pesticide, the other resistance may be seen. Behavioral Resistance is the avoidance of the mechanism that enables new generation pests to contact the pesticide (Çakır ve Yamanel 2005).

Environmental stresses such as pesticides, radiation, temperature, humidity, competition, disease parasites, constantly force living organisms. Strong individuals, populations and communities have to adapt themselves genetically to these ever-changing conditions to ensure their continuity. For this reason, they have developed a number of resistance mechanisms. These mechanisms are divided into two: Target-Site Mechanisms and Detoxification Mechanisms. Resistance mechanisms in each insect can be determined using biochemical and molecular methods. Knowing the resistance mechanisms, cross resistance helps to determine the spectrum, facilitates the selection of alternative insecticides and provides detailed allows mapping (Cygler et al., 1993)

Structural resistance is the resistance resulting from the body properties of the pest. It develops adaptation in the form of low contact of the harmful body with the drug or preventing the drug from moving to the place where it will act. Physiological resistance is that the pest is immune to pesticide. For example, the exoskeleton may be less permeable to pesticide, store harmful pesticide in its body or discard it without damage. It is the most important form of resistance and occurs in very large amounts with the use of synthetic pesticides. Cross resistance is the resistance developed against a group of pesticides to pesticides in other groups (Çakır ve Yamanel 2005).

2.3.1. Antibiosis

Antibiosis is a biological interaction between two or more organisms that is detrimental to at least one of them; it can also be an antagonistic association between an organism and the metabolic substances produced by another. Examples of antibiosis include the relationship between antibiotics and bacteria or animals and disease-causing pathogens. The study of antibiosis and its role in antibiotics has led to the expansion of knowledge in the field of microbiology. Molecular processes such cell wall synthesis and recycling, for example, have become better understood through the study of how antibiotics affect beta-lactam development through the antibiosis relationship and interaction of the particular drugs with the bacteria subjected to the compound. Antibiosis is typically studied in host plant populations and extends to the insects which feed upon them. "Antibiosis resistance affects the biology of the insect so pest abundance and subsequent damage is reduced compared to that which would have occurred if the insect was on a susceptible crop variety. Antibiosis resistance often results in increased mortality or reduced longevity and reproduction of the insect (Anonymus 2020).

In certain cases antibiosis cannot be clearly separated from antixenosis because of the extreme deterrent chemicals and physical factor(s) in the plant cultivar. In other words, the deterrent chemicals and toxins in the plant are sometimes difficult to distinguish. Similarly, some of the morphological characteristics of the plant such as leaf trichomes or tissue toughness, are so critical for the insect to be able to react to their host plant, it's difficult to distinguish between antixenotic and antibiotic mechanisms of resistance. Furthermore, there are often overlaps between the morphological and biochemical bases of resistance. The antibiotic properties of the host plant maybe expressed as constitutive or induced resistance against herbivores (Levin 1976).

2.3.2. Antixenosis

Antixenosis means something that keeps a guest away. It appears that the term has the de-sirable quality of conciseness, and it is a reasonable, parallel term to antibiosis. It is meant to convey the idea that the plant is bad host; therefore, it is avoided (Kogan and Ortman 1978).

Antixenosis is the resistance mechanism employed by the plant to deter or reduce colonization by insects. Generally, insects orient themselves toward plants for food, oviposition sites, and for shelter. However, due to certain characteristics, the plant may not be utilizable and may deter the insects. In certain situations, even though the insects may come in contact with the plant, the antixenosis characteristics of the plant do not allow the insect to colonize. Sometimes the antixenosis mechanism is so effective that the insects starve and die (Painter 1968).

The antixenosis mechanism of resistance may be closely linked with the structural morphology of spikelets small glume size and the extent of glume closure and the length of glume, palea, lemma, anther and style. Antixenosis detrimentally affects insects as they attempt to use plants for food, ovipositioning, or shelter. For example, globrous or hairy leaf surface could be non-preferred plant trait for some insects such as white flies, aphids, etc. The resistant plant is then rejected by the pest as an unsuitable host. Therefore, obviously antixenosis is the most preferred mechanism of resistance due to its ability to prevent the insect attack (Kalaisekar et al. 2016).

2.3.3. Tolerance/Recovery

Tolerance is a genetic trait of a plant that protects it against an insect population which would damage a susceptible host variety, so that there is no economic yield loss or lowering of the quality of the plant's marketable product. Tolerance is often confused with a low level of resistance or moderate resistance. The mechanism of tolerance is distinct from antixenosis and antibiosis (Panda, N. and Heinrichs 1983). Tolerance does not affect the rate of population increase of the target pest but does raise the threshold level.

Tolerance is an adaptive mechanism for the survival of the plant, and is more or less independent of the effect upon the insect. This type of host plant resistance refers strictly to resultant effects and not mechanisms. (Panda, N. and Khush, G.S., 1995) Tolerance is also called recovery resistance is the ability of the plant to withstand or recover from damage caused by insect. In case of shoot fly, some genotypes of sorghum are able to produce tillers when the main shoot is killed which are more resistant to shoot fly attack (Blum 1969; Dogget et al., 1970; Dogget 1972). High-plant recovery (Sharma et al., 1977) high rate of tiller survival, faster growth of tiller, high rate of growth (Blum 1972) are some of the characteristics of resistant varieties.

3. MATERIAL AND METHOD

It is known that the main damage of *Lygus* for eggplant is to the flower stem. For this reason, eggplant plants were evaluated by meristem and stalk observation method. The study was carried out during April 2018 - May 2019 and study materials were provided by Rijk Zwaan Seed Co.

3.1. Plant Material

In this thesis, seven types of eggplants supplied by Rijk Zwaan seed company were used in the study. 250 different plants from 7 different eggplant species were used. 250 plants were set up in two replications. In the second repetition, the plants were randomly ordered. Edge numbers are prevented from coming back to the edge and edge effect is minimized. It was aimed to observe a total of 3,000 plants with $250 \times 2 = 500$ numbers and 6 plants in each number.

These species are shown in Table 1.

Table 3. 1. Eggplant species that used in this study

FAMILY	SOLANACEAE
SPECIES	<i>Solanum anguivi</i> (2 gen.)
	<i>Solanum incanum</i> (1 gen.)
	<i>Solanum linnaeanum</i> (1 gen.)
	<i>Solanum macrocarpon</i> (62 gen.)
	<i>Solanum melongena</i> (170 gen.)
	<i>Solanum rubetorum</i> (1 gen.)
	<i>Solanum tomentosum</i> (13 gen.)
TOTAL GENOTYPE 250 genotype	

3.1.1. Experimental Region

The study was conducted with eggplant plants in open area in Korkuteli district of Antalya (Figure 3.1).



Figure 3. 1. Region that we carried out this study

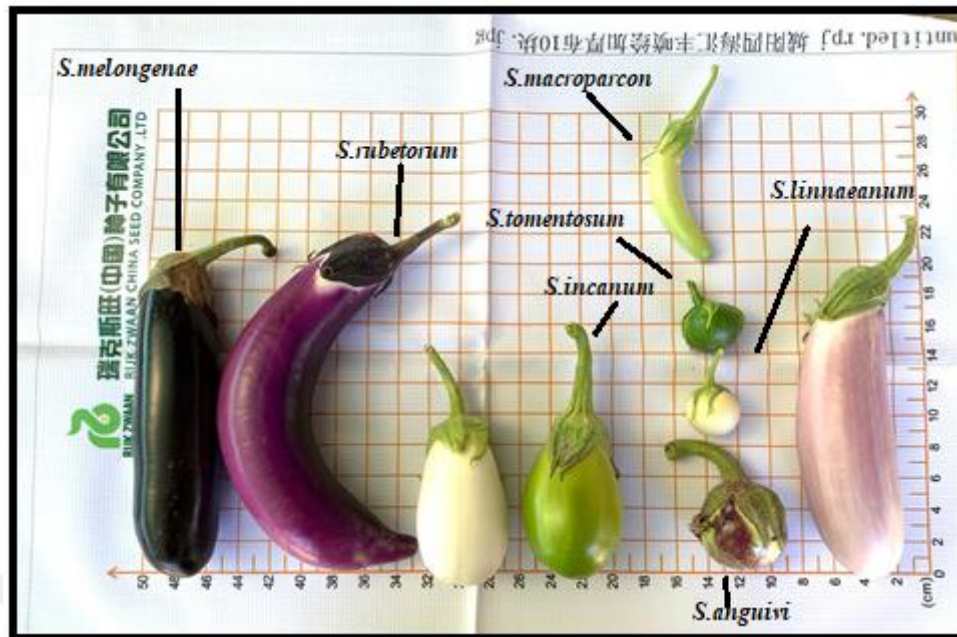


Figure 3. 2. Pictures of Melongena, Macrocarpon, Tomentosum, Anguivi, Incanum, Rubetorum, Linnaeanum

The aim of testing plants at seedling stage (young plant) was that *Lygus spp* damage to the meristem tissue was observed earlier. As it is known, it only causes the flowers to fall out without opening by sucking flower stems. In the growth stage of the plant, it directly damages the meristem by absorbing the tips. After the flowers are open we saw that meristem damage continues to decrease. In this study all damage types of *Lygus spp* are shown (Figure 3.3).

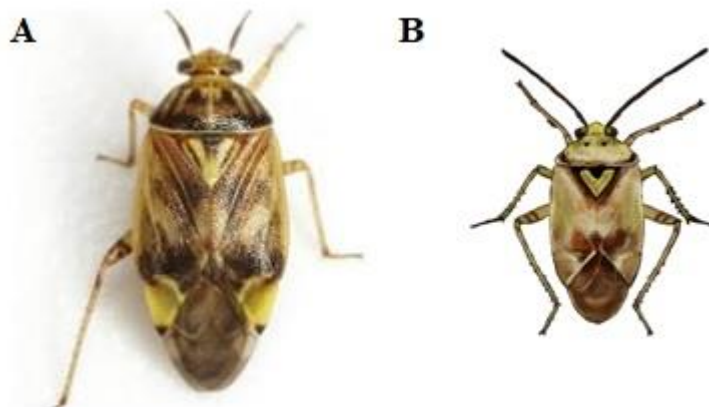


Figure 3. 3 A: Picture of *Lygus lineolaris*; B: Picture of *Lygus hesperus*

3.2. Method

We already tested our materials before this project to get information from the materials we will use. We conducted a young-plant test in the greenhouse in the

Netherlands in 2018. We only score meristem damage because the plants were too young to produce flowers. And we had a chance to get some information about our materials.

In this thesis, 250 different plants from 7 different eggplant species were used. 250 plants were set up in two replications. In the second repetition, the plants were randomly ordered. Edge numbers are prevented from coming back to the edge and edge effect is minimized. It was aimed to observe a total of 3,000 plants with $250 \times 2 = 500$ numbers and 6 plants in each number.

Table 3. 2. *Lygus* in eggplant test

Send seeds from NL:	week 7
Seeds arrive in TU:	week 10-13
Sowing:	week 14
Planting:	week 19
Natural infection <i>Lygus</i>	week 23-26
Phenotyping	week 24-35 (June-August)
Remove test	before week 36

We would expect to have enough natural infection with *Lygus* based on infection in previous years. We do not expect severe infection with other diseases. However, thrips, orobanche and spider mite could affect our plants.

3.2.1. Observation method

In this study, meristem damage, flower stem damage and fruit formation were evaluated 0 to 4 (0=Resistant, 1=R-Ls, 2=Ls, 3=Ls-S, 4=Susceptible). The various observations made at different dates are shown in Table 3.3.

Table 3. 3. Observations timeline

Dates	Observations
18.06.2019	Meristem damage, flower damage and leaf damage (probably <i>Spodoptera exigua</i>)
4.07.2019	Meristem damage and flower damage
16&17.07.2019	Meristem damage, flower damage and presence of fruit
18.07.2019	Meristem damage and presence of fruit

We would like to investigate the correlation between these recordings. Along the way, the absorption of leaf damage appeared to be mainly caused by damage from *Spodoptera exigua*.

4. RESULTS

Within the scope of this study, the aim was to find a resistance source for *Lygus* spp.. This is the first study conducted on eggplant related to this pest (*Lygus* spp.).



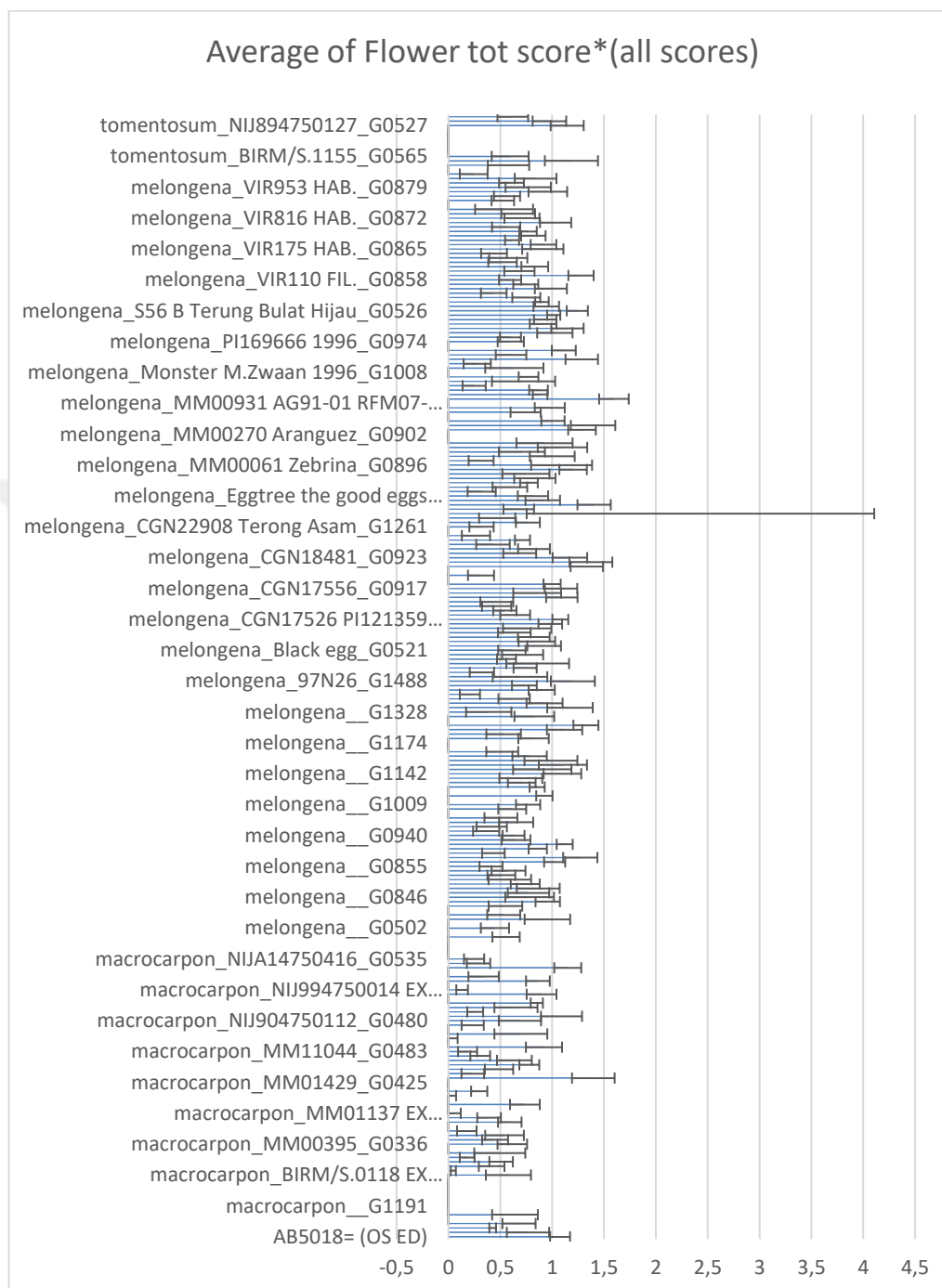
Figure 4. 1. Flower damage caused by *Lygus* spp

Row Labels	Count of Fruit	Average of Fruit2	StdDev of Fruit2
macrocarpon_NIJ994750024_G0640	10	38,1	52,80667045
tomentosum_NIIA24750061_G0549	11	45,36363636	33,23634374
anguivi_RNL155_G0559	6	85,5	40,67800388
Grand Total	2893	3,25095057	7,667128419



Figure 4. 2. Scores of resistant materials

After natural infection we started our observations. Results of observation method are demonstrated in Table 4.1 to Table 4.10.

Table 4. 1. Average of flower total scores

Average of damaged flowers (0 to 5 plants for each pilot)

We count the damaged flowers for each number and take their averages, to see how much they are effected from *Lygus* and we want to compare our material between them.

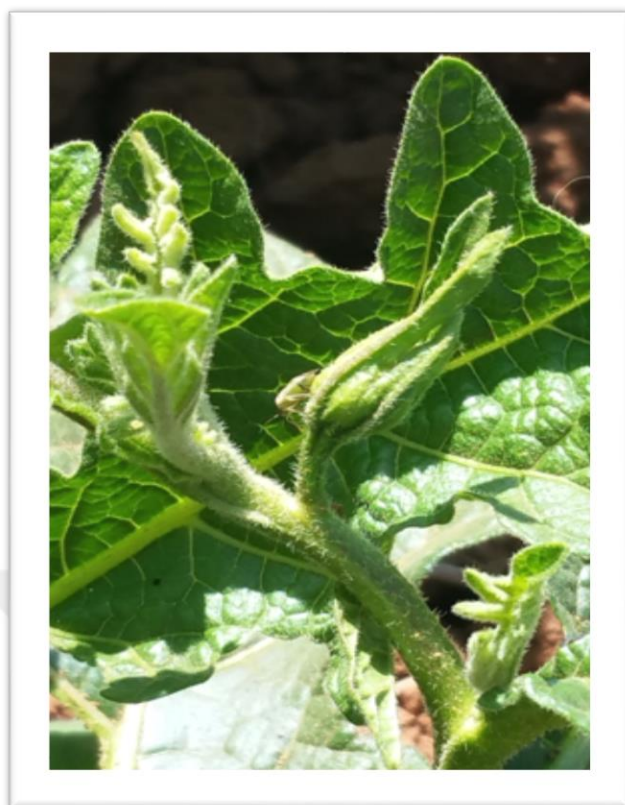
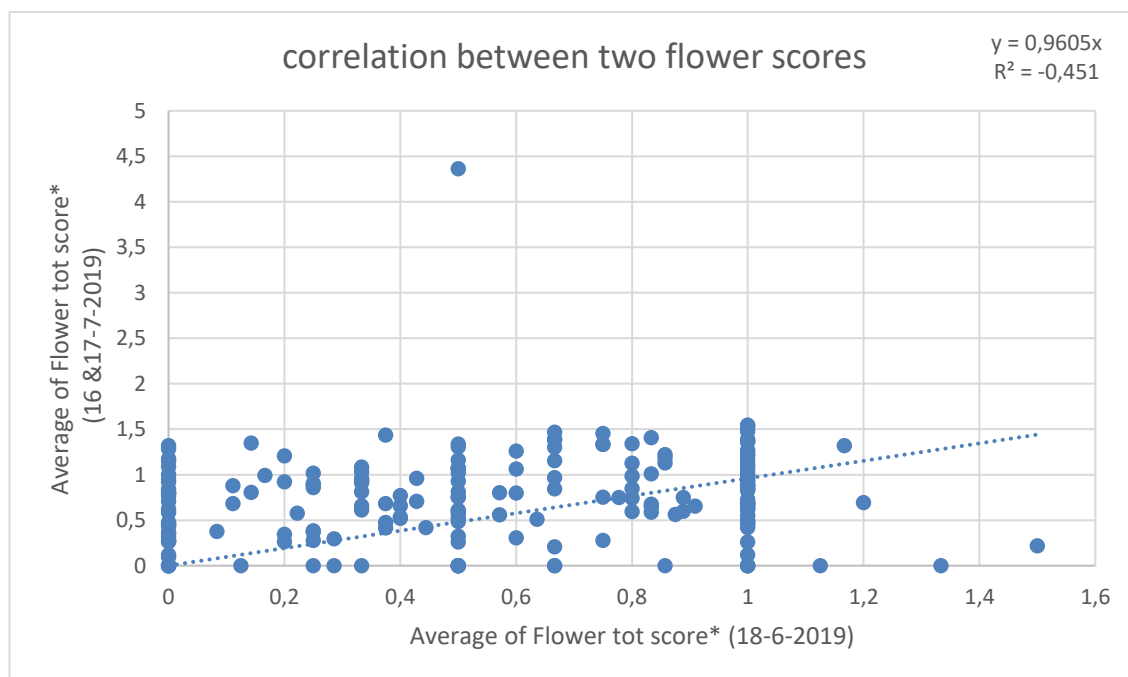


Figure 4. 3. Flower damage

Table 4. 2. Correlation between two flower scores

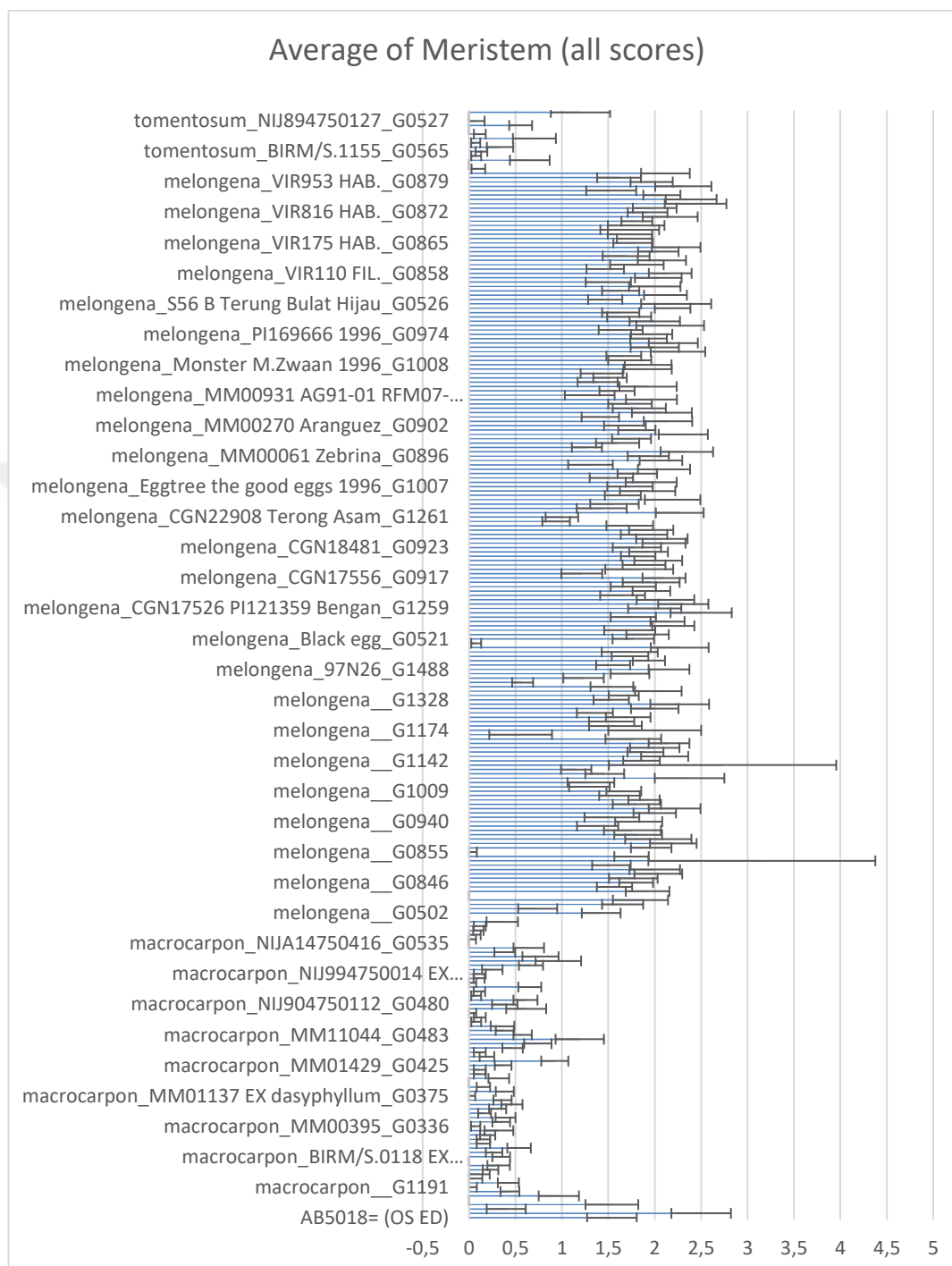


In this table we want to show the correlation between two flower damage scores . Correlation between this two scores is almost 0 .

Table 4. 3. Average of flower total score (16&17.07.2019)

Average of damaged flowers (0 to 5 plants for each pilot)

We count the damaged flowers at different timelines to better see and evaluate how they are affected by *Lygus*.

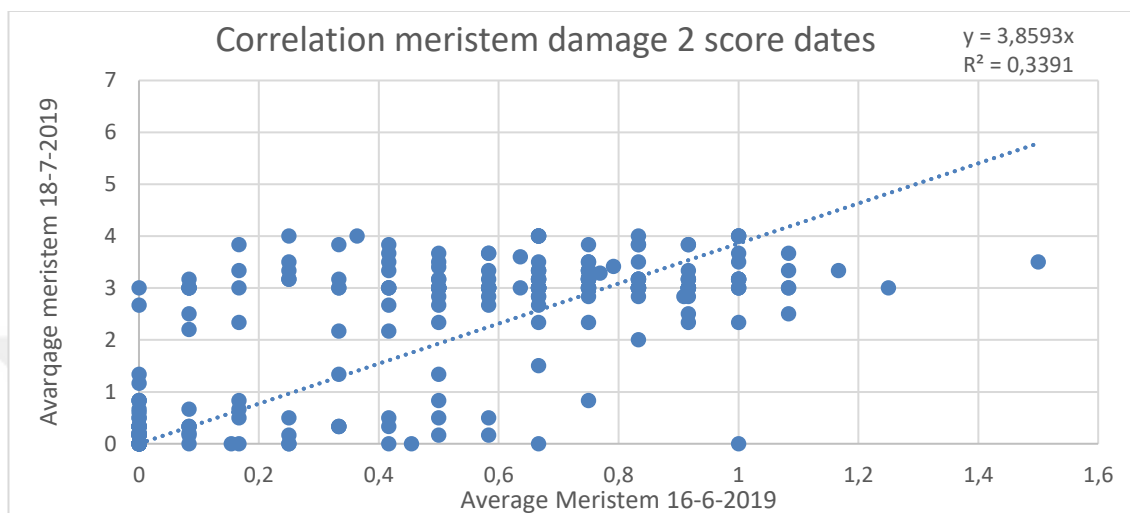
Table 4. 4. Average of Meristem

Average of damaged meristem (0 to 5 plants for each pilot)

We count the damaged meristems for each number and take their averages, to see how much they are effected from Lygus and we want to compare our material between them. Meristem damage observation was taken in addition to the fact that it would not be sufficient to observe only flower damage, especially before the plants formed flowers.

Unfortunately, we noted during the scores for the next resistant number that it doesn't look like *S.melongena*. If we find *S.melongena* it would be much more easy to work on them in Breeding programs. But most of our resistant materials are *S.macrocarpon*.

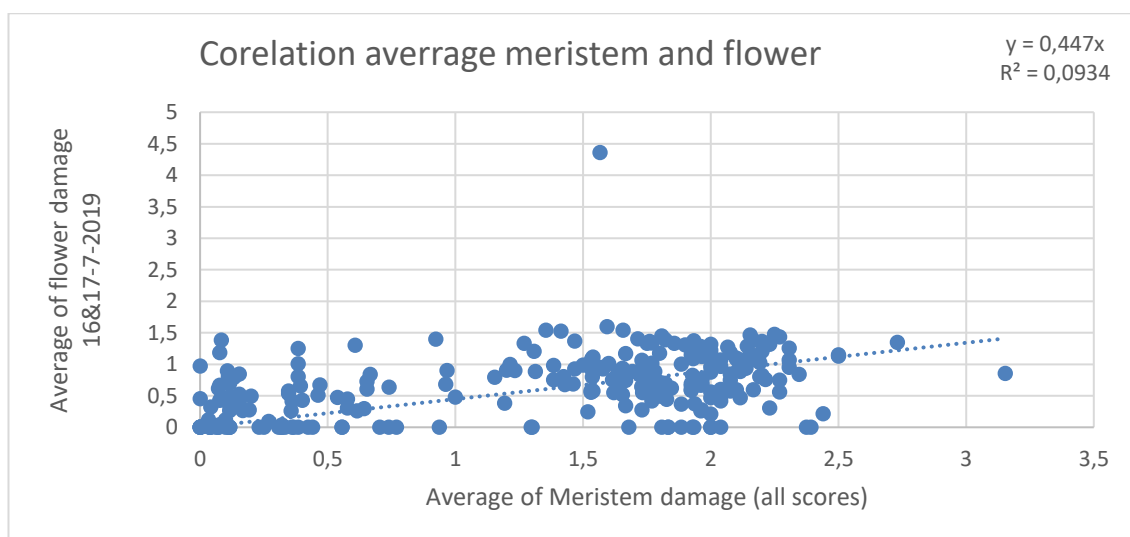
Table 4. 5. Correlation meristem damage 2 score dates



[number of damaged meristem(bottom) & number of damaged flower(left)]

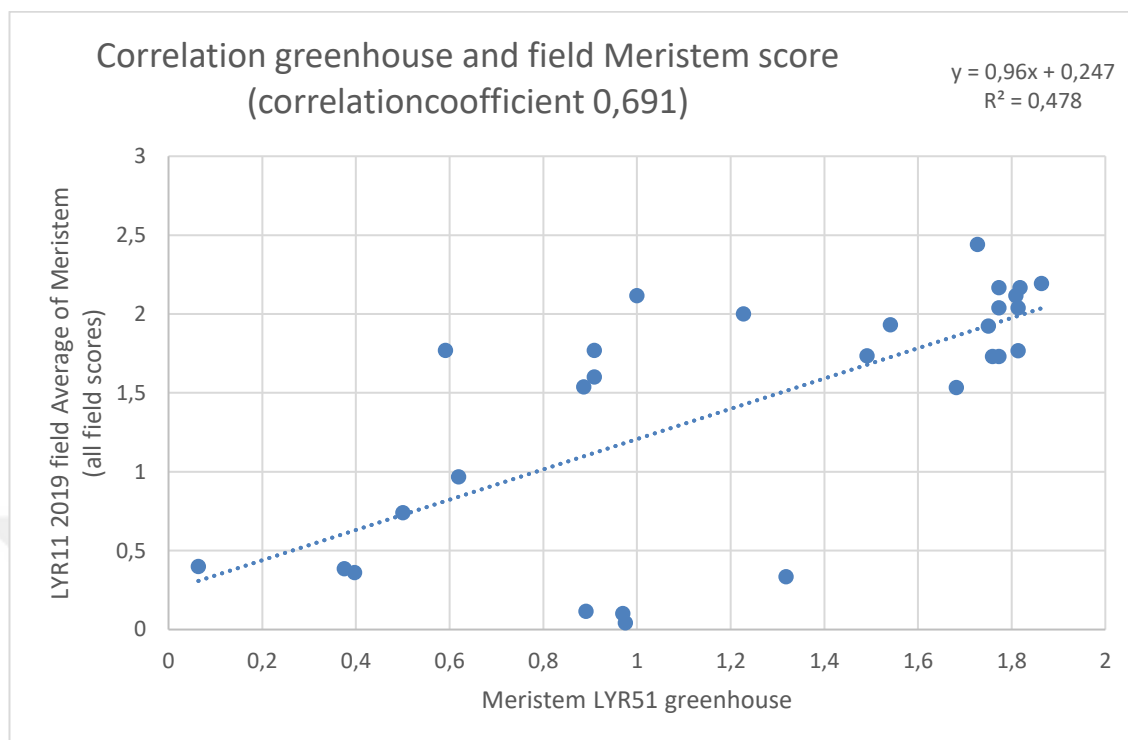
The correlation between two meristem scores looks almost reproducible and might be acceptable. So we focus the meristem scores more than flower scores.

Table 4. 6. Correlation average meristem and flower

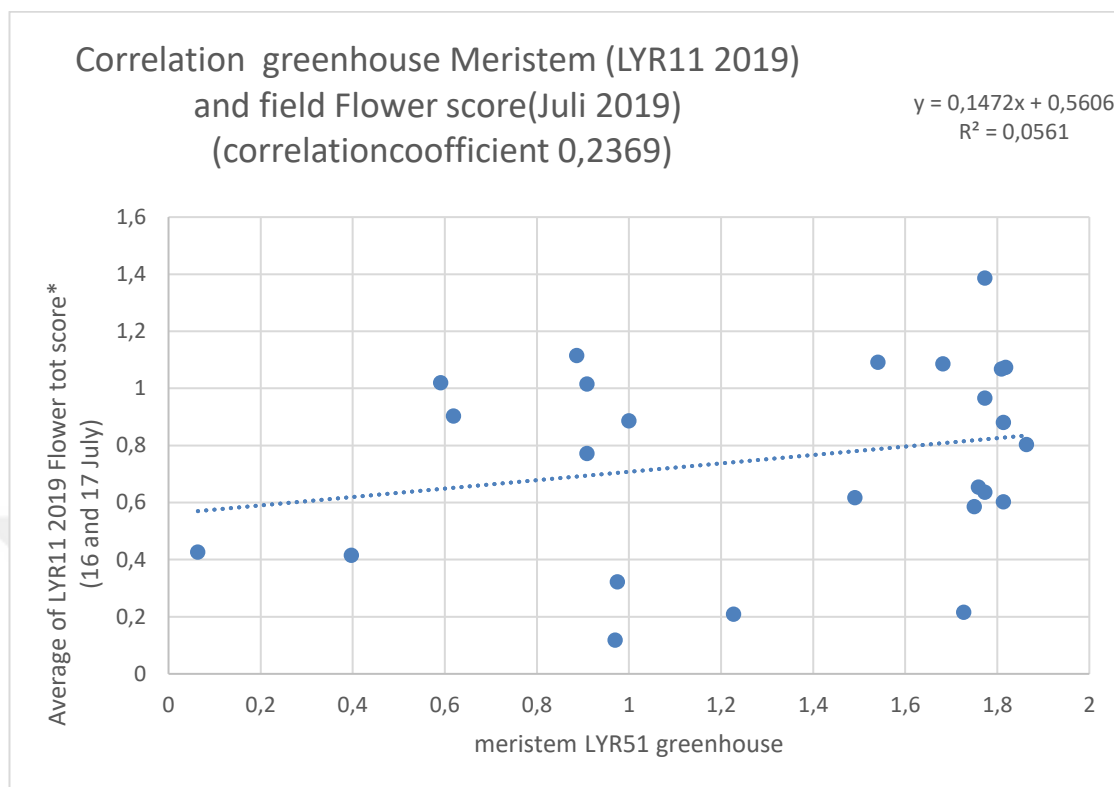


[number of damaged meristem(bottom) & number of damaged flower(left)]

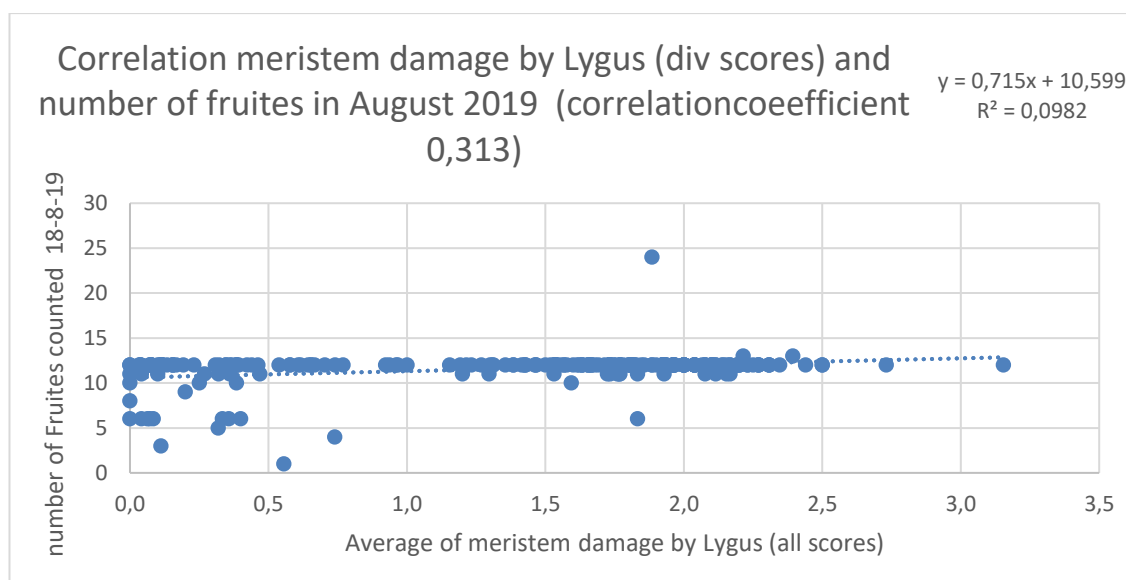
There is no significant correlation between flower and meristem damage in the field, but flower score is useful to compare with the greenhouse test.

Table 4. 7. Correlation greenhouse and field meristem score

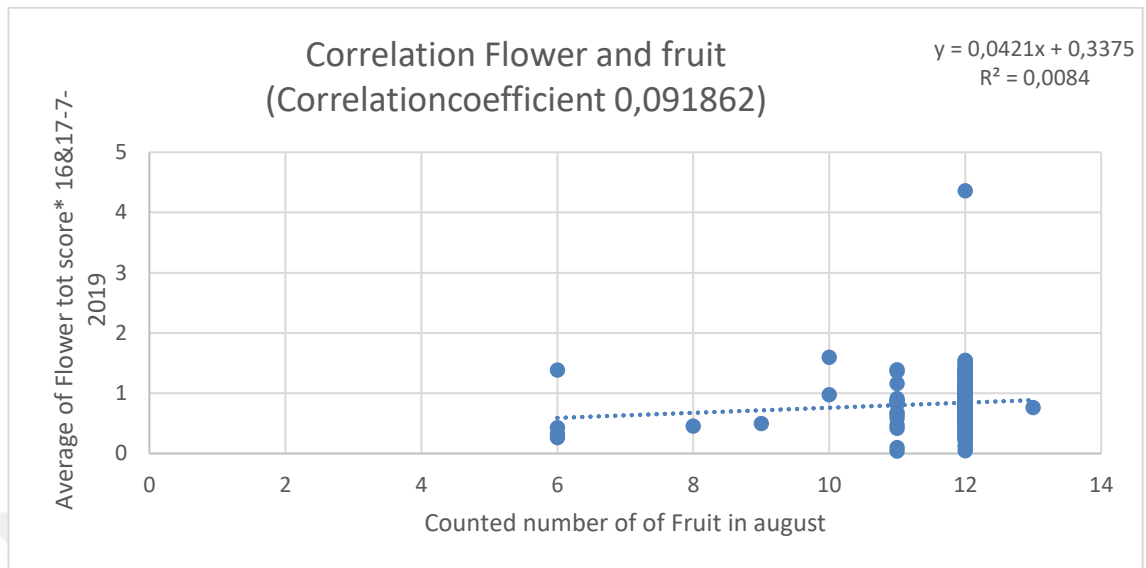
Last year, we tested our materials as a young plant test and got information about them. And we find out that there is a good correlation between the two tests.

Table 4. 8. Correlation greenhouse meristem (LYR11) and field flower score (July 2019)

We also scored meristem damage on the eggplant plants, to see if they are related or not. And we couldn't find significant correlation between flower and greenhouse meristem damage.

Table 4. 9. Correlation meristem damage by Lygus and number of fruits in August

Fruit score has no correlation with meristem scores.

Table 4. 10. Correlation flower and fruit

Fruit score has no correlation with flower scores also.

5. DISCUSSION

Poor correlations were found between meristem phenotypes of the Turkey field test compared with phenotypes from the tests at Netherlands (R-squared between 0.0 and 0.3).

We came to conclusion that flower damage score is quiet time consuming and it is really difficult to reproduce data, but meristem damage score seems to be more reproducible. In that case we also scored meristem damage on the eggplant plants.

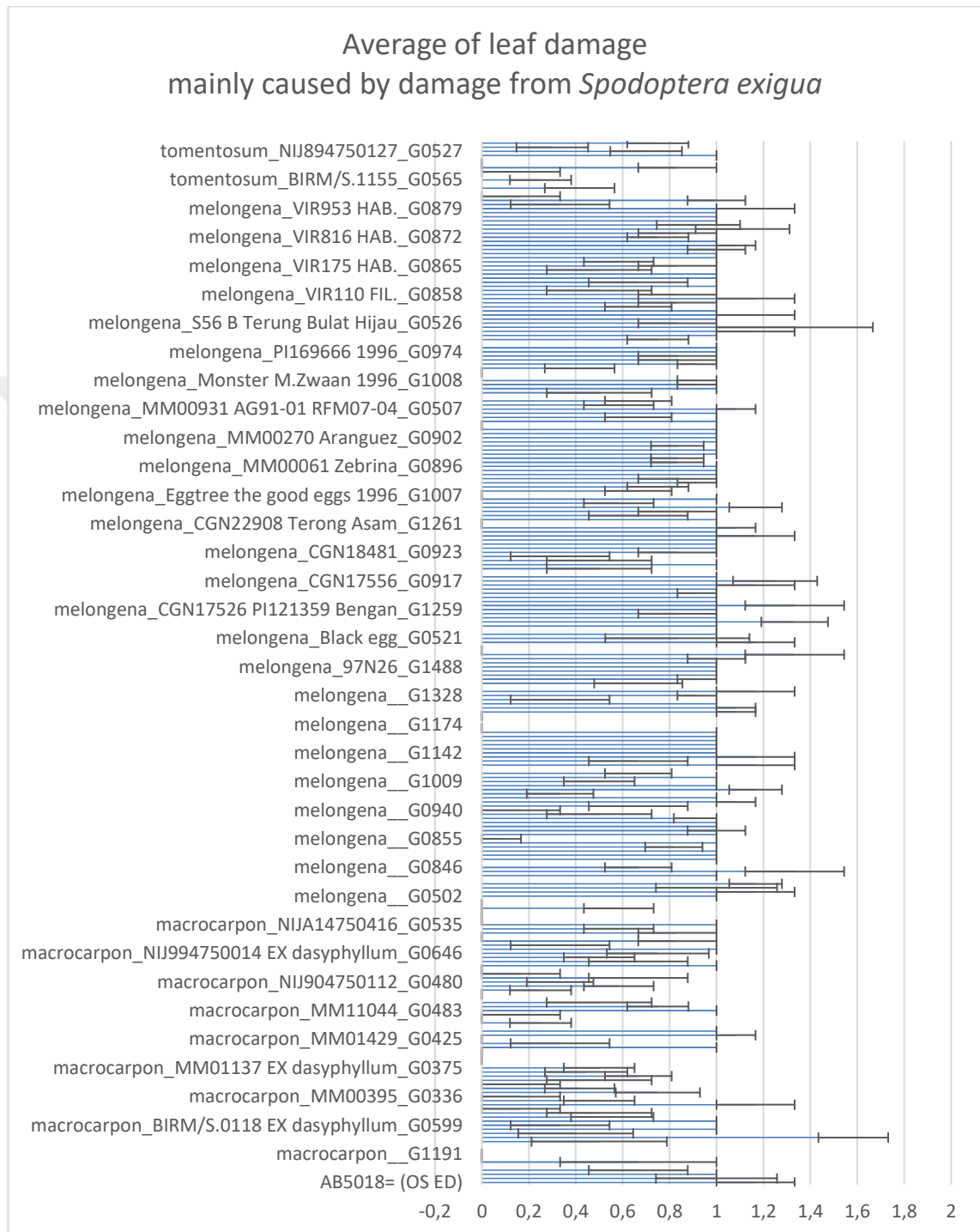
We also scored the fruits produced under *Lygus spp.* infection on plants, but it was really difficult the compare them, because the study involved different wild eggplant species that have big differances between fruit shapes and amount of fruits per plant.

We find that meristem damage observation at greenhouse and field has significant correlation between them. This caused us to take the meristem score as the main factor in this thesis.

After seeing Orobanche and Colorado beetle damage on our plants in trial, we also scored them. And we checked the correlations between them because we saw that colorado beetles feeds on orobanche leafs also (Table 5.1 to Table 5.4).

We couldn't find a similar study involving *Lygus spp.* resistance in eggplant. But we saw that *Lygus spp.* is a polyfag pest at least 130 economically important plants have been recorded as Tarnished Plant Bug host plants, including 21 of the 30 most important crops (ranked by area) in the United States (Young 1986).

Table 5. 1. Average of leaf damage mainly caused by damage from probably *Spodoptera exigua*.

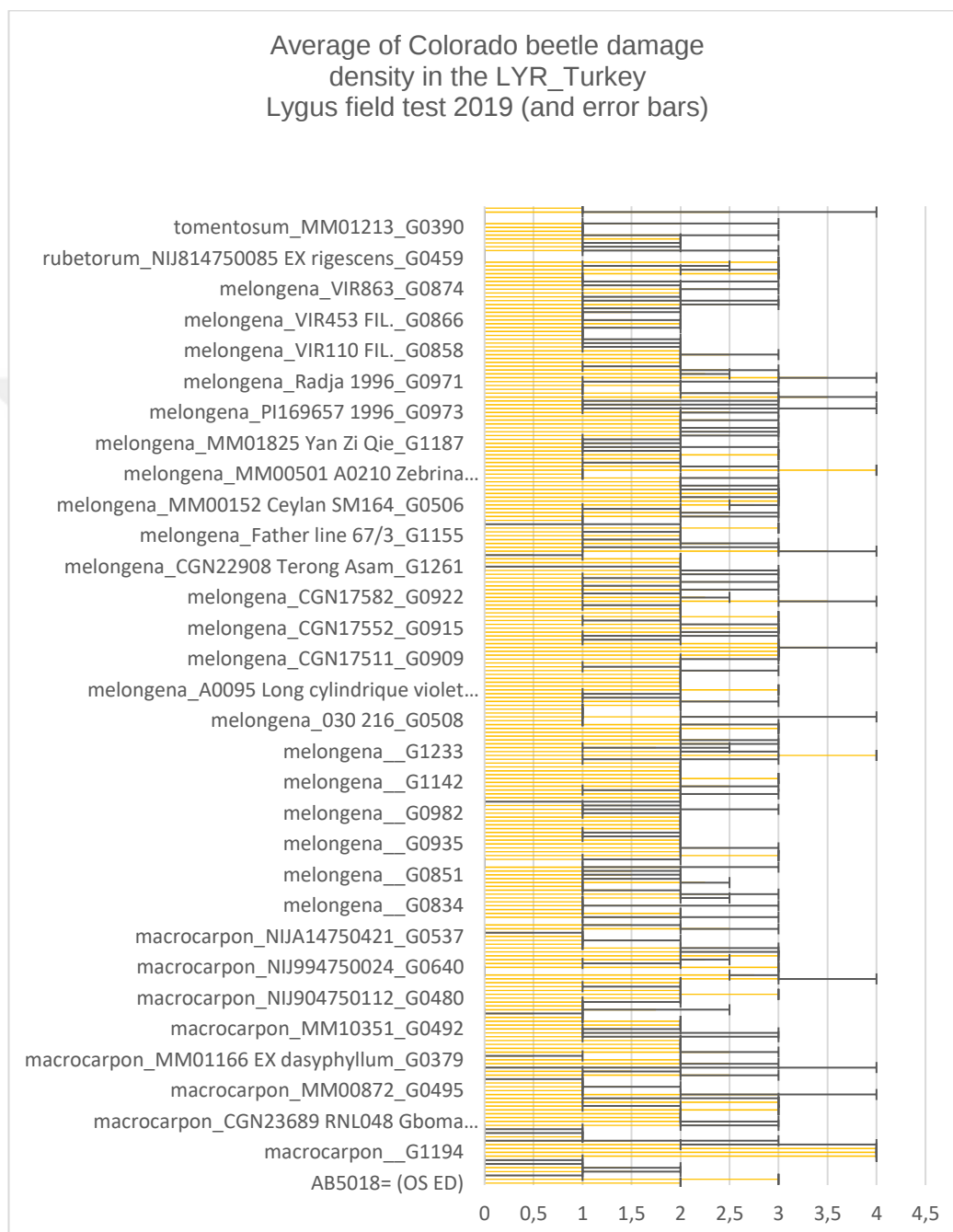


(0=R, 1=R-Ls, 2=Ls, 3=Ls-S, 4=S)

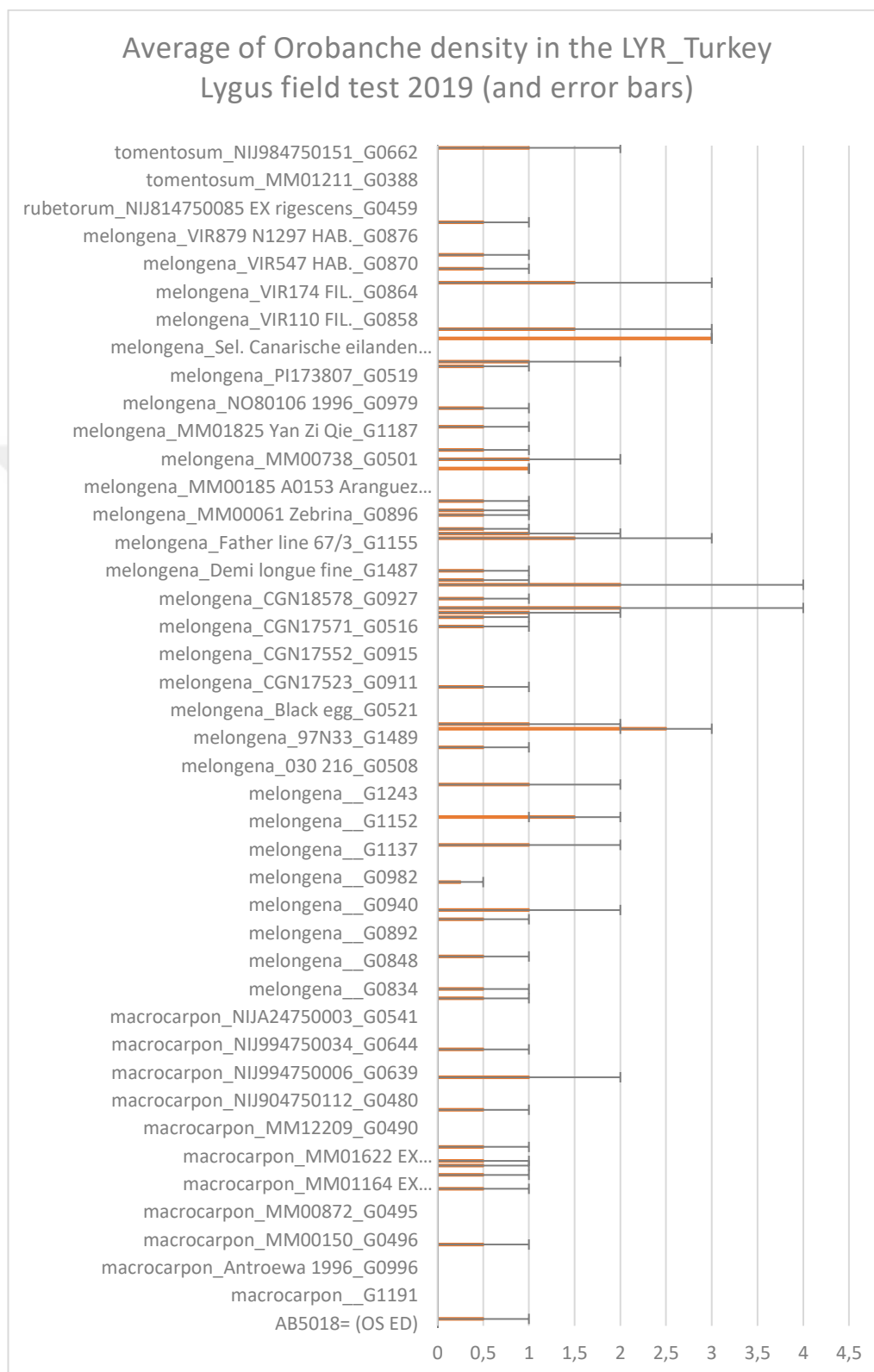
Along the way, the score of leaf damage appeared to be mainly caused by damage from Probably *Spodoptera exigua*. mid-August score is made for a total impression of the damage of Colorado beetle and Orobanche density.

(0=R No Colorado beetle damage and, 1=R-LS, 2=LS,3=LS-S, 4=S Severe beetle feeding on the leaves and a lot of Orobanche).

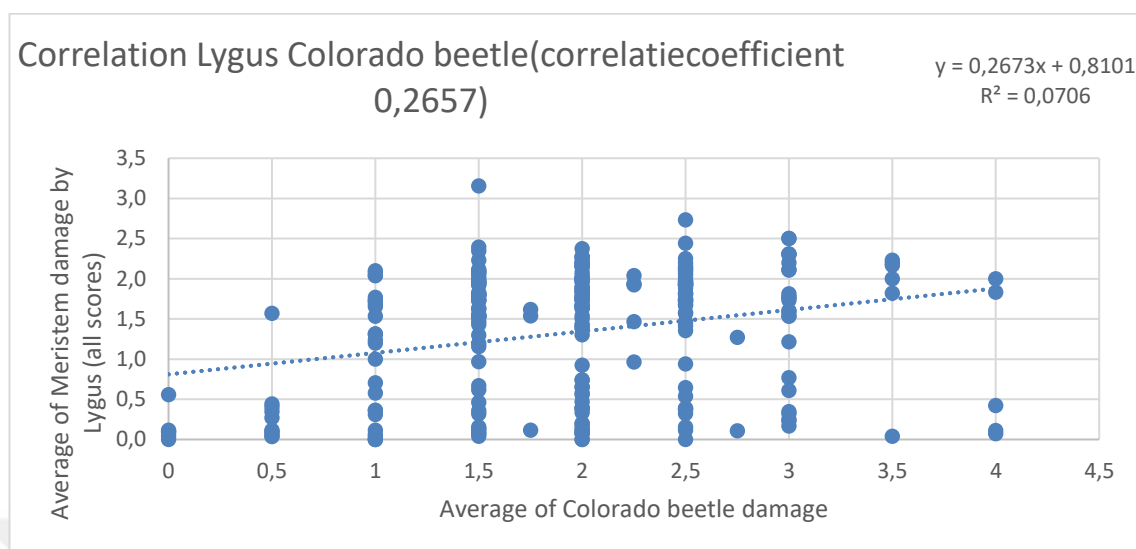
Table 5. 2. Average of Colorado beetle damage density for Lygus field test



We saw that colarado beetles also feeds from orobanche leafs, and this makes our observations unclear.

Table 5. 3. Avarage of Orobanche density for Lygus field test

We couldn't find any path in our materials for this parasite. They show themselves randomly, it depends of the soil infection.

Table 5. 4. Correlation Lygus and Colorado beetle

There is no significant correlation between Colorado beetle score and orobanche density score in the field, because Colorado beetles also feed from orobanches.

6. CONCLUSION

Eggplant is economically one of the most important crop from Solanaceae family. It is rich in nutrients (vitamins) for human health. Producing eggplant is ranked third after tomato and potato in general.

There are several diseases and pests infecting eggplant. *Lygus* spp. is one of the emerging pest for eggplant production in open field. Currently, there is no efficient solution to protect the crop from this pest. Pesticides and cultural methods are either costly or not effective. The most preferred and economical approach for management of this pest would be exploitation of plant resistance.

We came to the conclusion that the observation of meristem damage is the most correct method. We have observed that flower and fruit observation is not effective on such a wide variety of materials.

In general, *Macrocarpon* accessions were found to be more resistant in this test. Therefore, we should test the MM1127 and MM12209 BILs for *Lygus* resistance. The GNL.559 (*anguivi*), GNL.549 (*tomentosum*), GNL.640 (*melongena*), GNL.855 (*melongena*), and GNL.674 (*melongena*) accessions produced larger amount of fruits and should be re-tested. The GNL.855 is known to be resistant to Fruit and Shoot Borer.

Our results showed that we successfully find the *Lygus* spp. resistance source within eggplant germplasm. This makes these genotypes available for use as sources of resistance in the breeding programs to develop new resistant eggplant lines / hybrids against this pest. Inheritance of resistance should be studied before backcross breeding is initiated to transfer the resistance genes / quantitative trait loci (QTL) into cultivated eggplant lines.

7. REFERENCES

- Akan, S., Demir, K., (2012). Patlıcan Yetiştiriciliği <http://www.tarimturk.com.tr>
- Anonim 1 http://www.harmanime.com.tr/haber/turkiyenin_dunya_uretiminde_5_sirada_bulundugu_sebze_patlican [Son erişim tarihi: 16.03.2019].
- Anonymus2 <http://www.wikizeroo.net/index.php?q=aHR0cHM6Ly9lbi53aWtpcGVkaWEub3JnL3dpa2kvRWdncGxhbnQ>
- Antwi, J., & Rondon, S. I. (2019). Molecular and Morphological Identifications Reveal Species Composition of *Lygus* (Hemiptera: Miridae) Bugs in Potatoes Fields in the Lower Columbia Basin of the United States. *Journal of economic entomology*, 112(1), 364-370.
- AVRDC (1996). AVRDC 1995 Raporu. Asya Sebze Araştırma ve Geliştirme Merkezi, Tainan, 42-45.
- Braga, P. C., Lo Scalzo R., dal Sasso M., Lattuada N., Greco V., Fibiani M. (2016). Characterization and antioxidant activity of semi-purified extracts and pure delphinine-glycosides from eggplant peel (*Solanum melongena* L.) and allied species. *J. Funct. Foods* 20, 411–421. 10.1016/j.jff.2015.10.032
- Candolle, A. De (1883). *Origine des Plantes Cultivées*. Librairie Germer Baillière et Cie. Paris.
- Chiarini, F. E., Moreno N. C., Barboza G. E., Bernardello G. (2010). Karyotype characterization of Andean Solanoideae (Solanaceae). *Caryologia* 63, 278–291. 10.1080/00087114.2010.589738
- Choudhury, B. 1995: Eggplant. In: Smartt, J.; Simmonds, N.W. (eds). *Evolution of crop plants*. Longman Scientific & Technical, Essex, UK, p. 464-465.
- Cygler, M., Schrag J.D., Susman J.L., Harel M., Silman I., Gentry M.K et al., (1993). Relationship between sequence conservation and three dimensional structure in large family of esterases, lipases and related proteins. *Protein Sci.* 2, 366.
- Çakır Ş., Yamanel Ş. (2005). Böceklerde İnsektisidlere Direnç. Gazi Üniversitesi Kırşehir Eğitim Fakültesi, Cilt 6, Sayı 1, 21-29
- Daunay, M.C., Lester, R.N., Dalmon, A., Ferri, M., Kapilima, W., Poveda-Aguilar, M., and Jullian, E. 1998. The use of wild genetic resources for eggplant (*Solanum melongena*) breeding. II. Crossability and fertility of interspecific hybrids. *Proceedings 10th Eucarpia Meeting on Genetics and Breeding of Capsicum and Eggplants*: 19-24.
- Daunay, MC (2008) Eggplant. *Handbook of plant breeding Vegetables II Fabaceae, Liliaceae, Solanaceae, and Umbelliferae*, p 163–220
- Daunay, M.C., Lester, R.N., Gebhardt, C., Hennart, J.W., Jahn, M., Frary, A., Doganla S., (2001). Genetic resources of eggplant (*Solanum melongena*) and allied species: a new challenge for molecular geneticists and eggplant breeders.

- Daunay, M.C., Lester, R.N., Laterrot H., (1991). The use of wild species for the genetic improvement of eggplant (*Solanum melongena*) and tomato (*Lycopersicon esculentum*). In Hawkes, J.G., Lester, R.N., Estrada, N. (ed.) *Solanaceae III: Taxonomy-Chemistry-Evolution*, Vol 3:389-412. The Linnean Society of London, Royal Botanical Gardens Kew, London, UK.
- Docimo, T., Francese G., Ruggiero A., Batelli G., De Palma M., Bassolino L., et al. . (2016). Phenylpropanoids accumulation in eggplant fruit: characterization of biosynthetic genes and regulation by a MYB transcription factor. *Front. Plant Sci.* 6:1233. 10.3389/fpls.2015.01233
- Doganlar S, Frary A, Daunay MC, Lester RN, Tanksley SD (2002) A comparative genetic linkage map of eggplant (*Solanum melongena*) and its implications for genome evolution in the Solanaceae. *Genetics* 161:1697–1711
- Doggett, H., & Majisu, B. N. (1972). Fertility improvement in autotetraploid sorghum. 3. Yields of cultivated tetraploids. *Euphytica*, 21(1), 86-89.
- FAO,(2019). FAOSTAT Production Databases. Available online at: <http://www.faostat.fao.org>(Accessed November 25, 2019).
- FAOSTAT, (2016). <http://www.fao.org/faostat/en/#data/QC>
- Frary, A., Doganlar, S. and Daunay, M. C. (2007) ‘Eggplant’, in *Vegetables*. Berlin, Heidelberg: Springer Berlin Heidelberg, pp. 287–313. doi: 10.1007/978-3-540-34536-7_9.
- Hanny, B. W., Cleveland, T. C., & Meredith Jr, W. R. (1977). Effects of tarnished plant bug, (*Lygus lineolaris*), infestation on presquaring cotton (*Gossypium hirsutum*). *Environmental Entomology*, 6(3), 460-462.
- Hollingsworth, R. G., Steinkraus, D. C., & Tugwell, N. P. (1997). Responses of Arkansas populations of tarnished plant bugs (Heteroptera: Miridae) to insecticides, and tolerance differences between nymphs and adults. *Journal of economic entomology*, 90(1), 21-26.
- Isshiki, S., Uchiyama, T., Tashiro, Y., & Miyazaki, S. (1998). RFLP analysis of a PCR amplified region of chloroplast DNA in eggplant and related *Solanum* species. *Euphytica*, 102(3), 295.
- Kalaisekar , A.,(2016). *Insect Pests of Millets: Systematics, Bionomics and Management*. 978-0-12-804243-4.
- Kalloo, G., Berg BO (1993) *Genetic improvement of vegetable crops*. Pergamon Press Ltd, Oxford, pp 587–604
- Kashyap, V., Kumar S., Collonier, C., Fusari, F., Haicour, R., Rotino G.L., Sihachak, R.D., Rajam. M.V., (2003). Biotechnology of eggplant. *Scientia Hort.* 97(1):1-25.
- Knapp, S., Vorontsova M. S., Prohens J. (2013). Wild relatives of the eggplant (*Solanum melongena* L.: Solanaceae): new understanding of species names in a complex group. *PLoS ONE* 8:e57039. 10.1371/journal.pone.0057039
- Kogan, M., Ortman E.F. Antixenosis-A New Term Proposed to Define Painter's “Nonpreference” Modality of Resistance. June 1978 DOI: 10.1093/besa/24.2.175

- Layton, A. C., Gregory, B. W., Seward, J. R., Schultz, T. W., & Sayler, G. S. (2000). Mineralization of steroidal hormones by biosolids in wastewater treatment systems in Tennessee USA. *Environmental Science & Technology*, 34(18), 3925-3931.
- Lester, R.N., (1998) 'No Title', Genetic resources of capsicum and eggplants. Xth Eucarpia Meeting on Genetic and Breeding of Capsicum and Eggplan, pp. 25–30.
- Levin D.A.,(1976).The chemical defences of plants to pathogens and herbivores. *Ann. Rev. Ecol. Syst.* 7:121-159.
- Levin R.A., Myers N. R., Bohs L. (2006). Phylogenetic relationships among the “spiny solanums” (*Solanum* subgenus *Leptostemonum*, Solanaceae). *Am. J. Bot.* 93, 157–169. 10.3732/ajb.93.1.157
- Mueller, S. C., C. G. Summers, and P. B. Goodell. (2003). A field key to the most common *Lygus* species found in agronomic crops of the central San Joaquin Valley of California. University of California, Division of Agriculture and Natural Resources Publication 8104, Oakland, CA.
- Pack, T.M., Tugwell, N.P., 1976. Clouded and tarnished plant bugs on cotton: a comparison of injury symptoms and damage on fruit parts. *Arkansas Agric. Exp. Stn. Report Series* 226, 17 pp.
- Painter, R.H.,(1968). Crops that resist insect provide a way to increase world food supply. *Kans. State Agric. Exp.Stn.Bull.*520,22pp.
- Panda, N.,Khush G. S.,(1995). Host Plant Resistance to Insects.
- Pearce, K., Lester, R.N., (1979). Chemotaxonomy of the cultivated eggplant-A new look at the taxonomic relationships of *Solanum melongena* L. In Hawkes J.G., Lester, R.N. & Skelding (ed.) *The biology and taxonomy of the Solanaceae*: 615-628. *The Linnean Society of London*, London, UK.
- Plazas, M., Andújar I., Vilanova S., Hurtado M., Gramazio P., Herraiz F. J., et al. (2013). Breeding for chlorogenic acid content in eggplant: interest and prospects. *Not. Bot. Horti. Agrobot.* 41, 26–35. 10.15835/nbha4119036
- Plazas, M., Prohens J., Cuñat A. N., Vilanova S., Gramazio P., Herraiz F. J., et al. . (2014). Reducing capacity, chlorogenic acid content and biological activity in a collection of scarlet (*Solanum aethiopicum*) and gboma (*S. macrocarpon*) eggplants. *Int. J. Mol. Sci.* 15, 17221–17241. 10.3390/ijms151017221
- Polignano, G., Uggenti P., Bisignano V., Della Gatta C. (2010). Patlıcan (*Solanum melongena* L.) ve müttefik türlerinde genetik sapma analizi . *Genet. Resour. Bitki Evol.* 57 , 171-181. 10.1007 / s10722-009-9459-6
- Raigón, M. D., Prohens J., Muñoz-Falcón J. E., Nuez F. (2008). Comparison of eggplant landraces and commercial varieties for fruit content of phenolics, minerals, dry matter and protein. *J. Food Comp. Anal.* 21, 370–376. 10.1016/j.jfca.2008.03.006
- Rotino, GL, Perri E., Acciarri N., Sunseri F., Arpaia S. (1997). Bitki ıslahı yoluyla böcek ve hastalıklara patlıcanın varyetal direncinin geliştirilmesi. *Gelişmiş. Hort. Sci.* 11 , 193-201.

- Sao, A. and Mehta N., Dirasat, *Agricultural Sciences*, Volume 37, No. 1, (2010). - 36 - © 2010 DAR Publishers/University of Jordan. All Rights Reserved. Heterosis and Inbreeding Depression for Fruit Yield and its Components in Brinjal (*Solanum melongena* L.)
- Snodgrass, C. K., Allen, D. H., Tuttle, J. R., Rotzoll, R. R., & Pax, G. E. (1996). U.S. Patent No. 5,500,650. Washington, DC: U.S. Patent and Trademark Office.
- Snodgrass, G. L., & Scott, W. P. (2002). Tolerance to acephate in tarnished plant bug (Heteroptera: Miridae) populations in the Mississippi River Delta. *Southwestern Entomologist*, 27(2), 191-200.
- Snodgrass, G. L., Gore, J., Abel, C. A., & Jackson, R. (2009). Acephate resistance in populations of the tarnished plant bug (Heteroptera: Miridae) from the Mississippi River Delta. *Journal of economic entomology*, 102(2), 699-707.
- Taher, D., Solberg S.O., Prohens J. (2017). World Vegetable Center Eggplant Collection: Origin, Composition, Seed Dissemination and Utilization in Breeding
- TUIK, (2017). <https://biruni.tuik.gov.tr/medas/?kn=92&locale=tr> [Son erişim tarihi: 13.05.2018].
- TUIK, (2018) <https://biruni.tuik.gov.tr/medas/?kn=92&locale=tr> [Son erişim tarihi: 26.03.2019].
- Vorontsova, M. S., Knapp S. (2012). A new species of *Solanum* (Solanaceae) from South Africa related to the cultivated eggplant. *PhytoKeys* 8, 1–11. 10.3897/phytokeys.8.2462.
- Young, O. P. (1986). Host plants of the tarnished plant bug, *Lygus lineolaris* (Heteroptera: Miridae). *Annals of the Entomological Society of America*, 79(4), 747-762.

RESUME

ŞÜKRÜ YILDIRIM

skryldrm33@gmail.com



EDUCATION INFORMATION

Master Degree 2017- 2020	Akdeniz University Faculty of Agriculture, Department of Agricultural of Biotechnology, Antalya
Bachelor Degree 2013-2017	Akdeniz University Faculty of Agriculture, Department of Plant Protection, Antalya

JOB INFORMATION

Junior Breeder 2017- Continue	Rijk Zwaan Seed Co.
----------------------------------	---------------------