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

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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

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Eggplant, an important species of Solanacae 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 (*Orobanche 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 PATLICAN (*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 karşılaşılmaktadır. *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 karşılaşılmıştır. *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 gözlemlenmişitr. 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 ikiside *S.macrocarpon* olup MM1127 ve MM12209 materyalleri olup iki materyalde %60'ın üzerinde dayanım göstermiştir.

ANAHTAR KELİMELER: 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

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	:	Severeal species
TÜİK	:	Türkiye İstatistik Kurumu

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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' (Sękara 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, whiteflys, 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 studywas 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 melongenae* L.) belongs to the large solanacae 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 Solanacae, 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.*

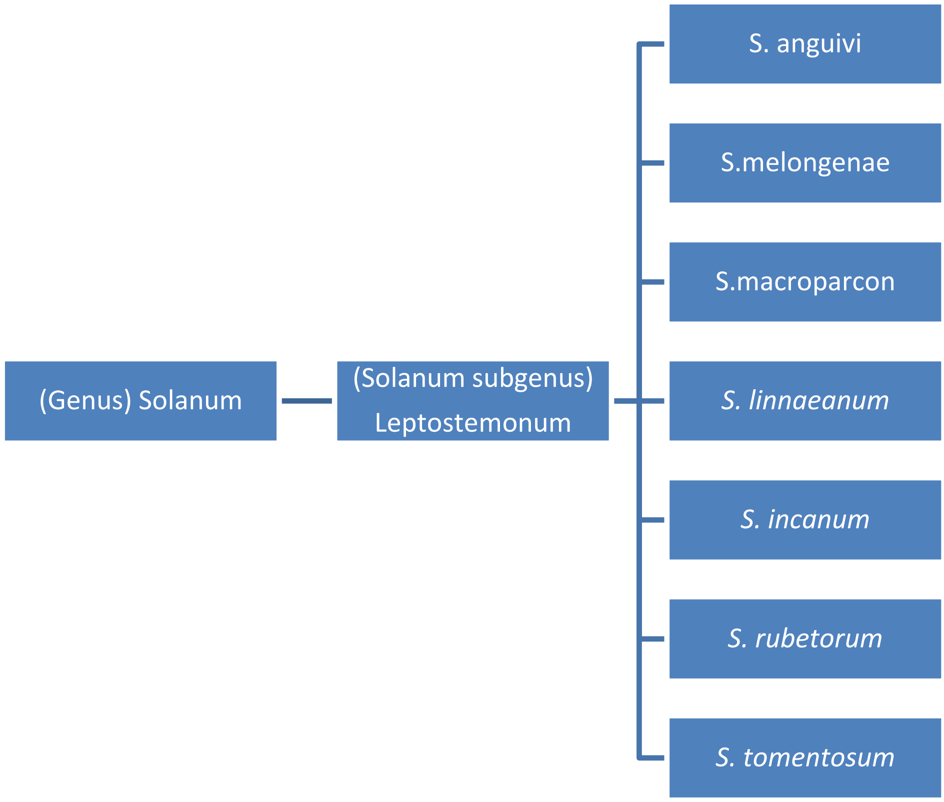


Figure 2. 1 Eggplant species used in the study

The basic chromosome number of eggplant is n = 12 (Chiarini et al. 2010) and 2n = 24 (Sękara 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-pronutum 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 characterictics of the plant such as leaf trichomes or tissue toughness, are so critical for the insect to be able to react totheir host plant, it’s difficult to distinguish between antixenotic and antibiotic mechanisims of resistance. Furthermore, there are often overlaps between the morphological and biochemical bases of resistance. The antibiotic properties of the host plant maybe expreced as constitutive or inducet 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 mechansim 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 stuations, even though the insects may come in contact with the plant, the antixenosis characterictics of the plant do not allow the insect to colonize. Sometimes the antixenosis mechanisms 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 determentally 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 protectcs it against an insect populationwhich would damage asusceptible 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 mechansim of tolerance is distinct from antixenosis and antibiosis (Panda, N. and Heinrichs 1983). Tolerance does not affect the rate of populationincrease 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 maib 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 x 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	*Solanum anguivi (2 gen.)*
	Solanum incanum (1 gen.)
	Solanum linnaeanum (1 gen.)
	Solanum macrocarpon (62 gen.)
	Solanum melongena (170 gen.)
	Solanum rubetorum (1 gen.)
	Solanum tomentosum (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

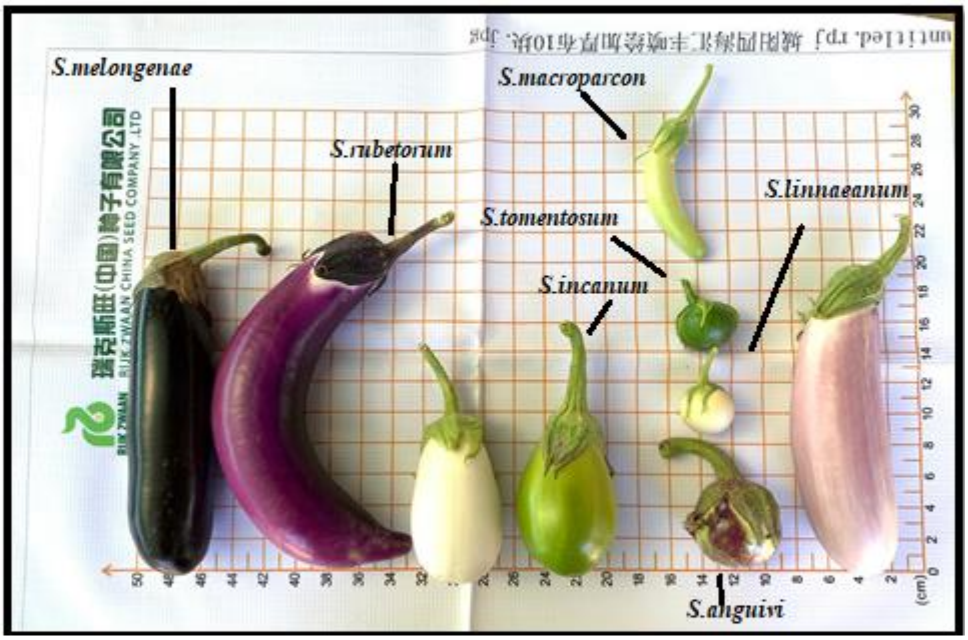


Figure 3. 2. Pictures of Melongena, Macrocarpon, Tomentosum, Anguivi, Incanum, Rubetorum, Linnaeanum

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).

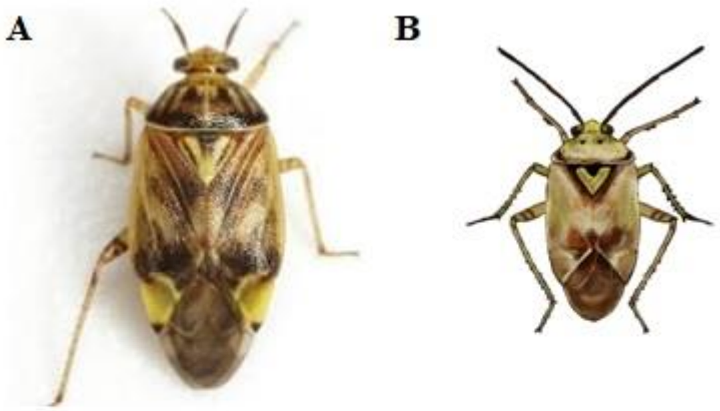


Figure 3. 3 A: Picture of *Lygus lineolaris*; B: Picture of *Lygus hesperus*

3.2. Method

We alraedy 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 x 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 Lygus	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 *Spodoptera exigua*)
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.).

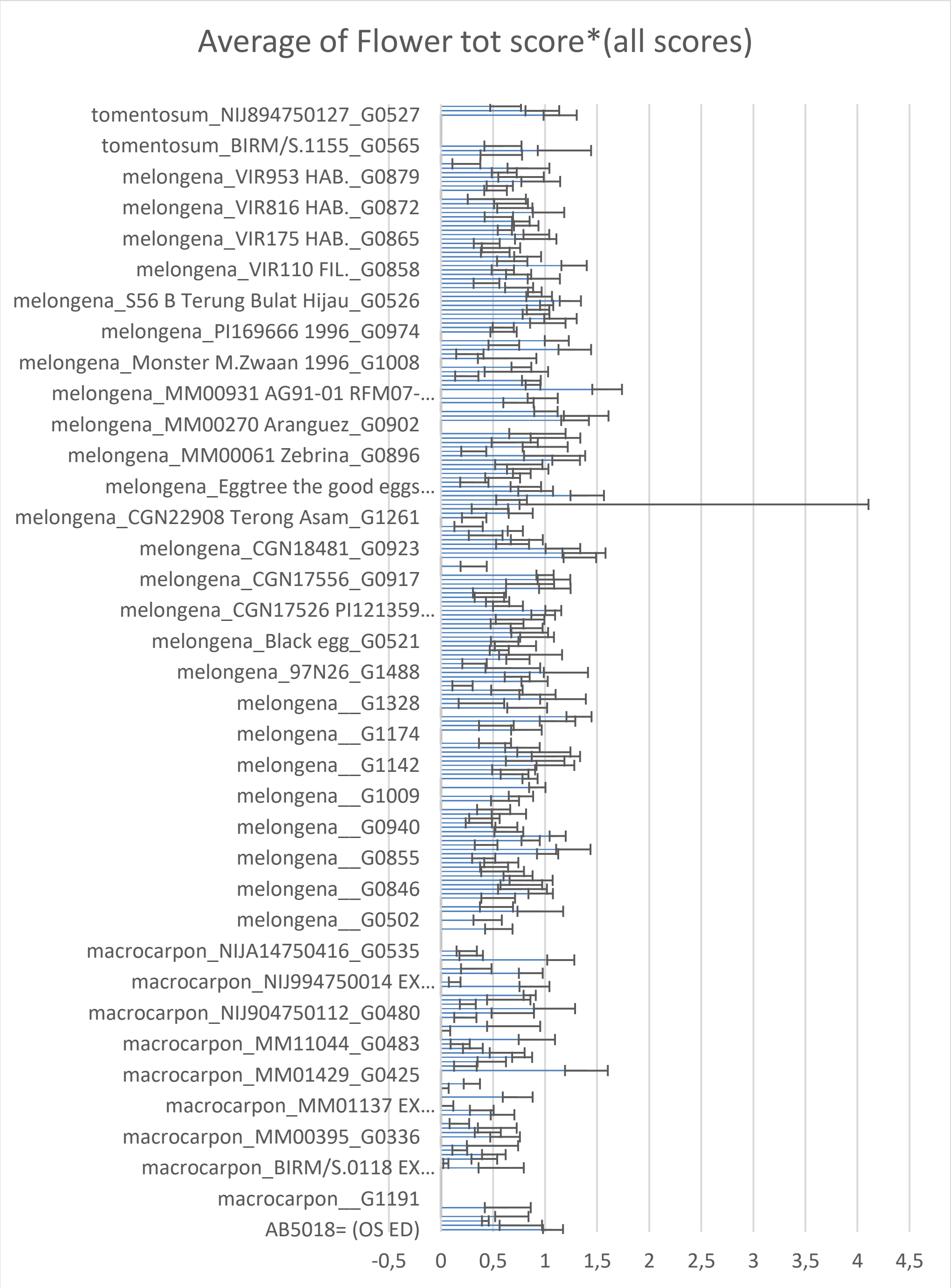
Figure 4. 1. Flower damage caused by *Lygus spp*

Row Labels	Count of Fruit	Average of Fruit2	StdDev of Fruit2
macrocarpon_NIJ994750024_G0640	10	38,1	52,80667045
tomentosum_NIJA24750061_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 demostrated 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.

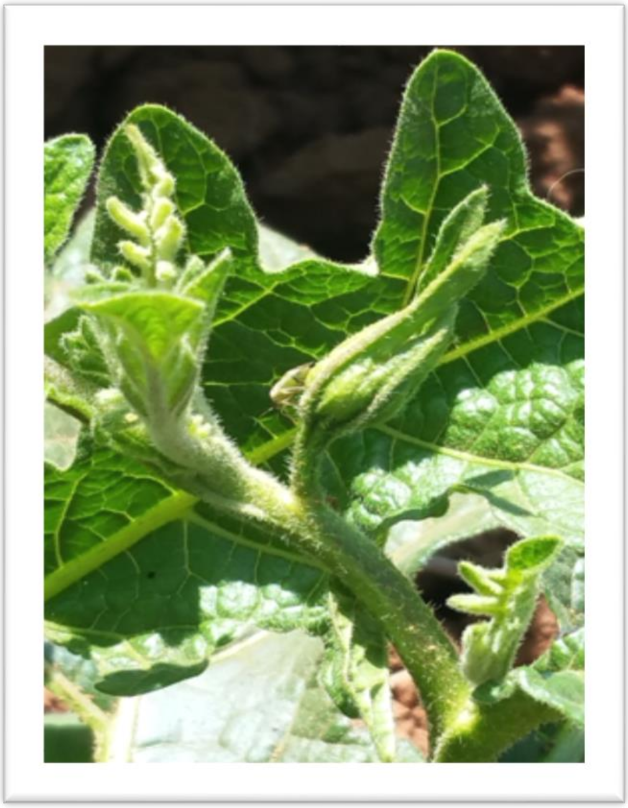
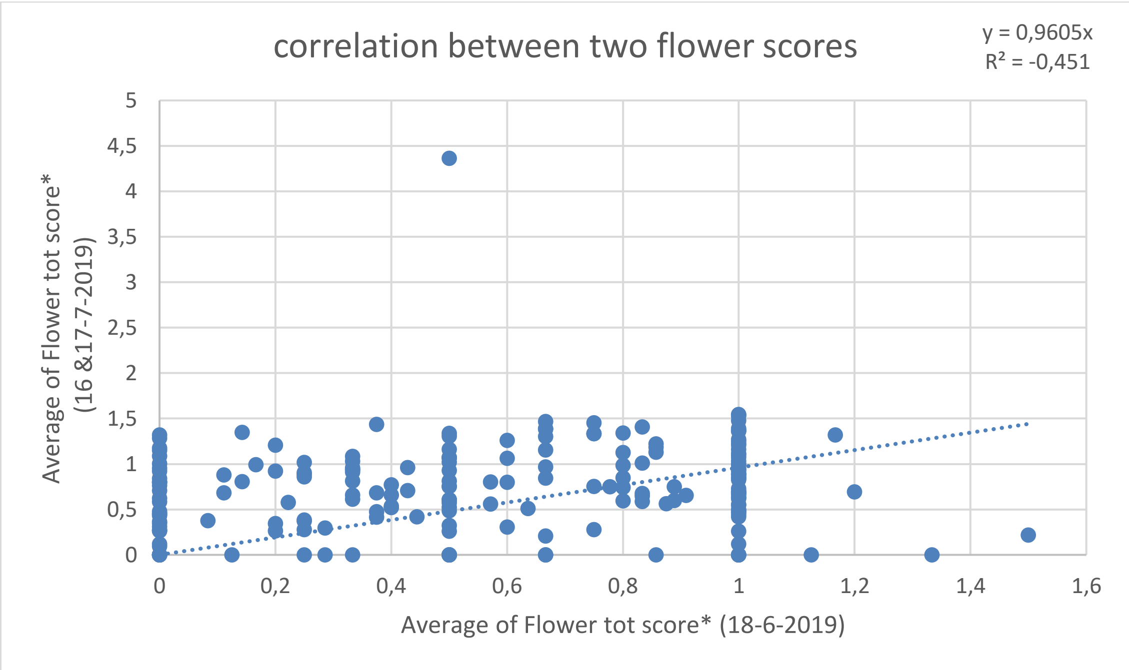


Figure 4. 3. Flower damage

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*.

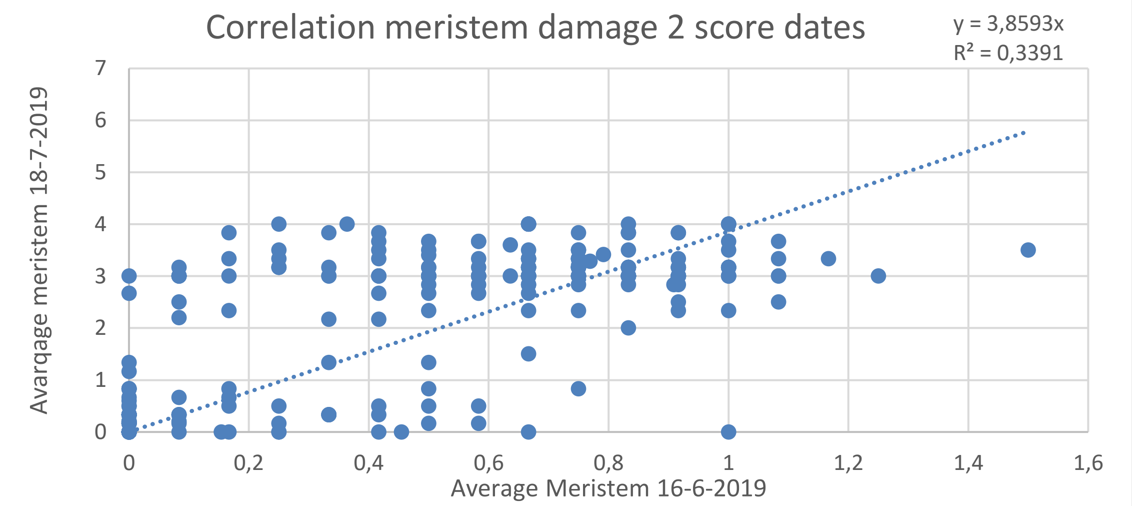
Table 4. 4. Average of Meristem

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 me much more easy to work on them in Breeding programs. But most of our resistant matrials are *S.macrocarpon*.

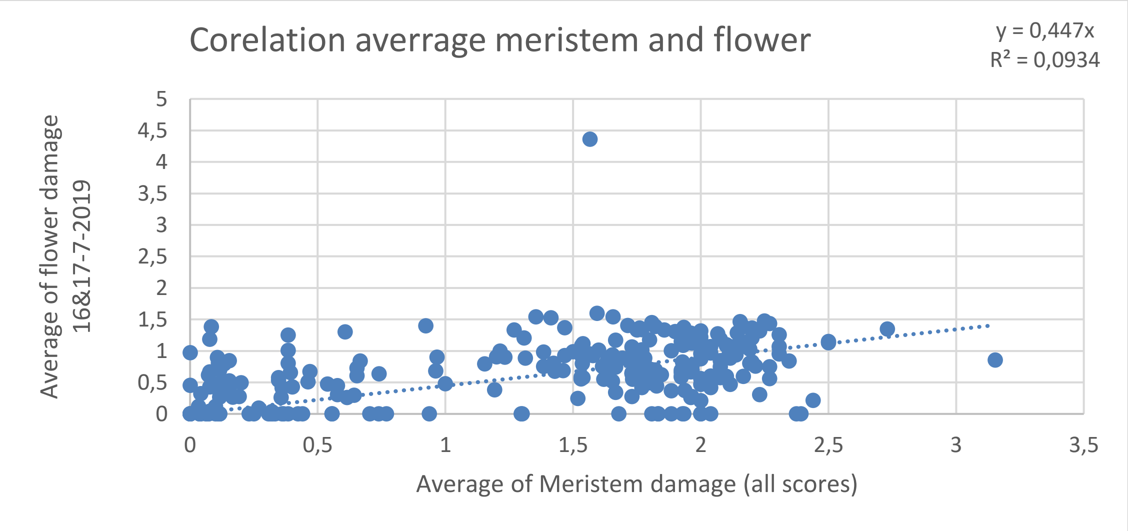
Table 4. 5. Correlation meristem damage 2 score dates



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

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

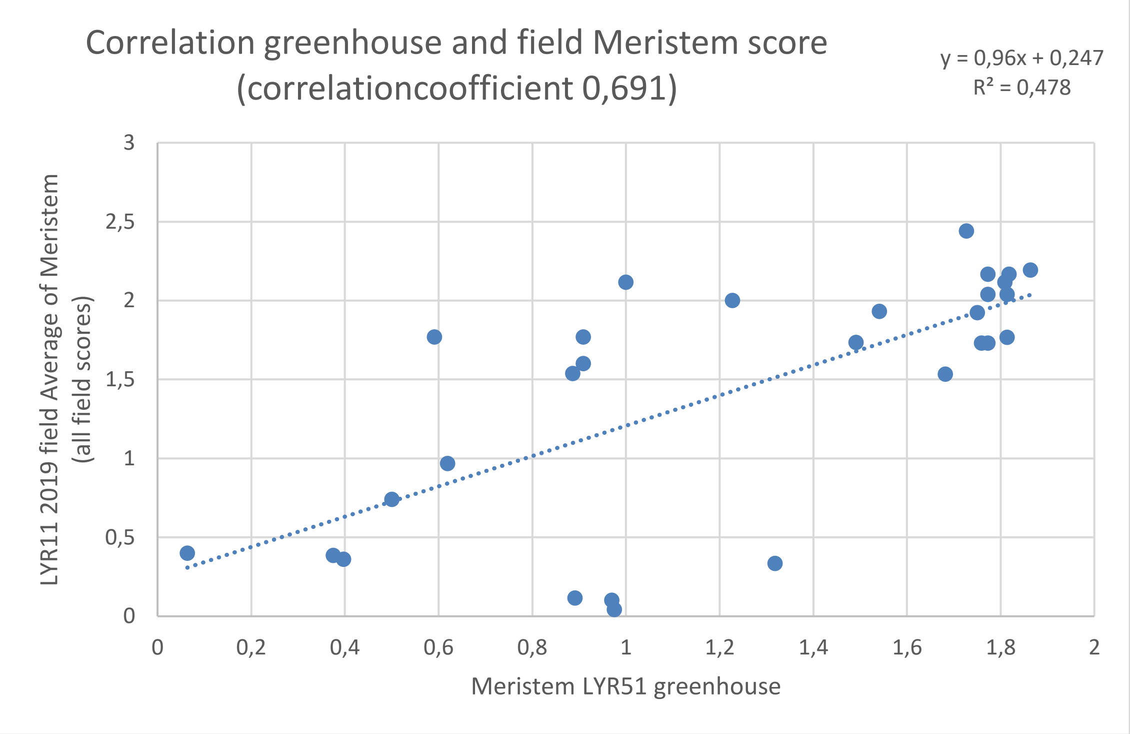
Table 4. 6. Correlation average meristem and flower



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

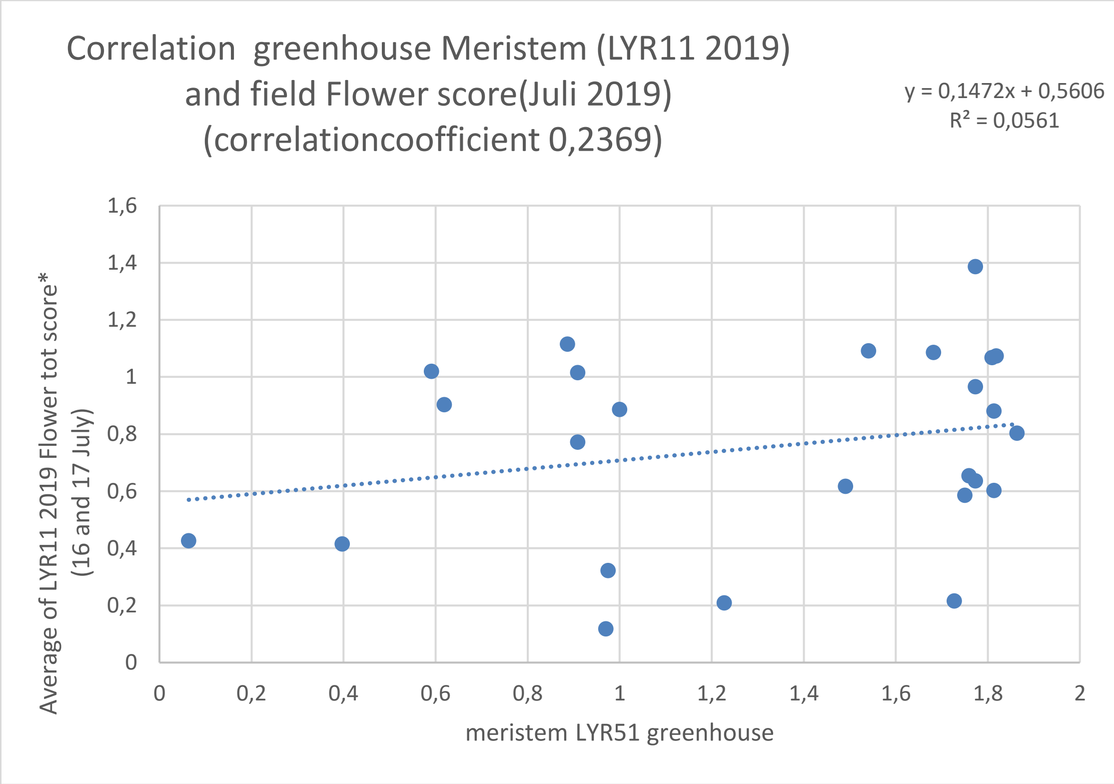
There is no significant correlation between flower and meristem damage in the field, but flower score is useful to compare with the greenhouse test.

Table 4. 7. Correlation greenhouse and field meristem score



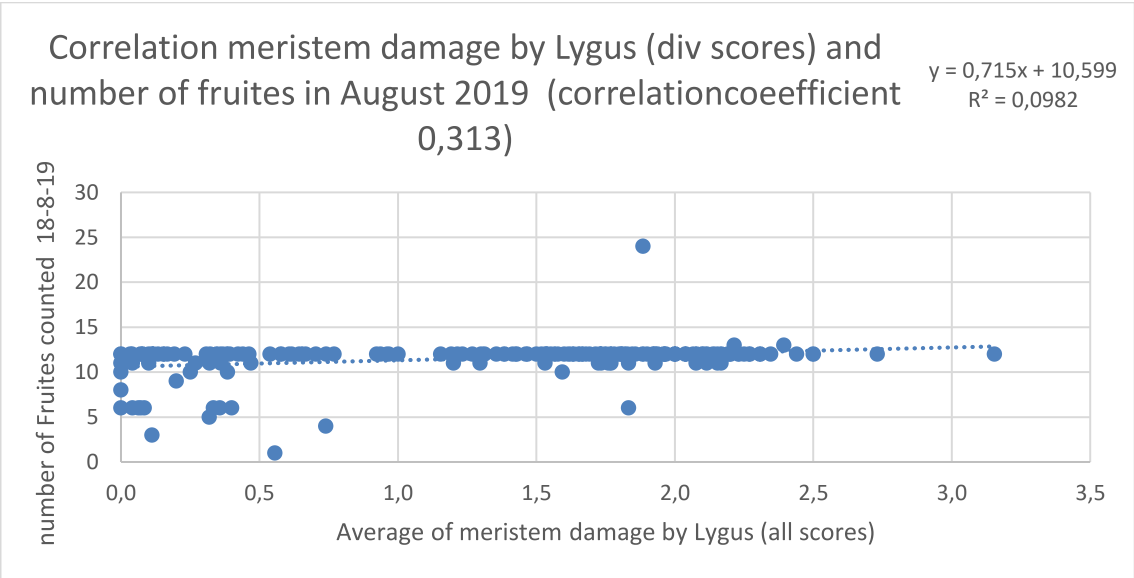
Last year, we tested our materials as a young plant test and got information about them. And we find out that there is a good correlation between the two tests.

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



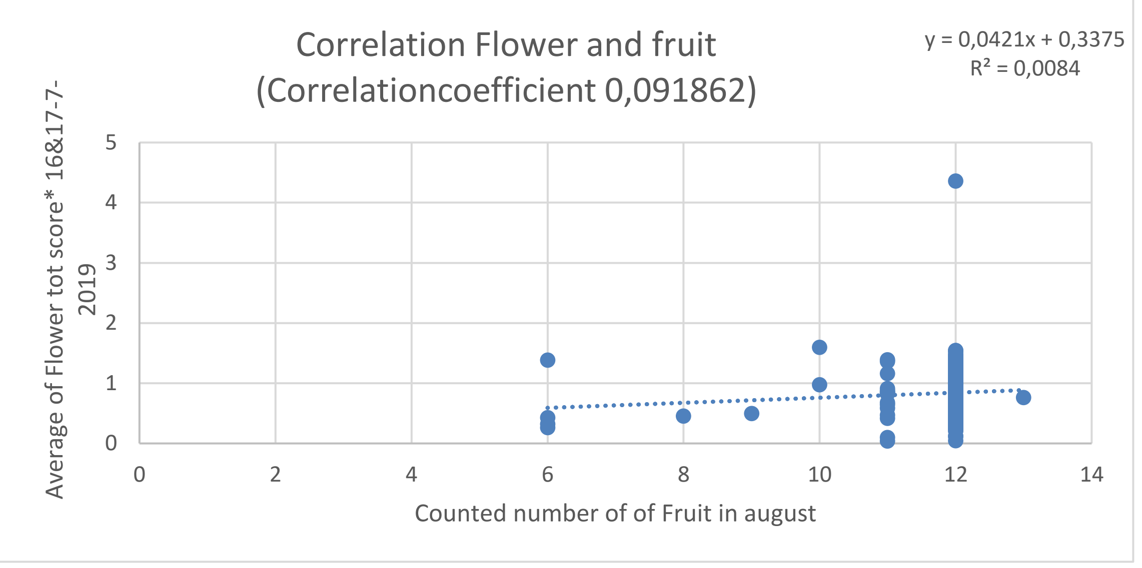
We also scored meristem damage on the eggplant plants, to see if they are related or not. And we couldn't find significant correlation between flower and greenhouse meristem damage.

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.

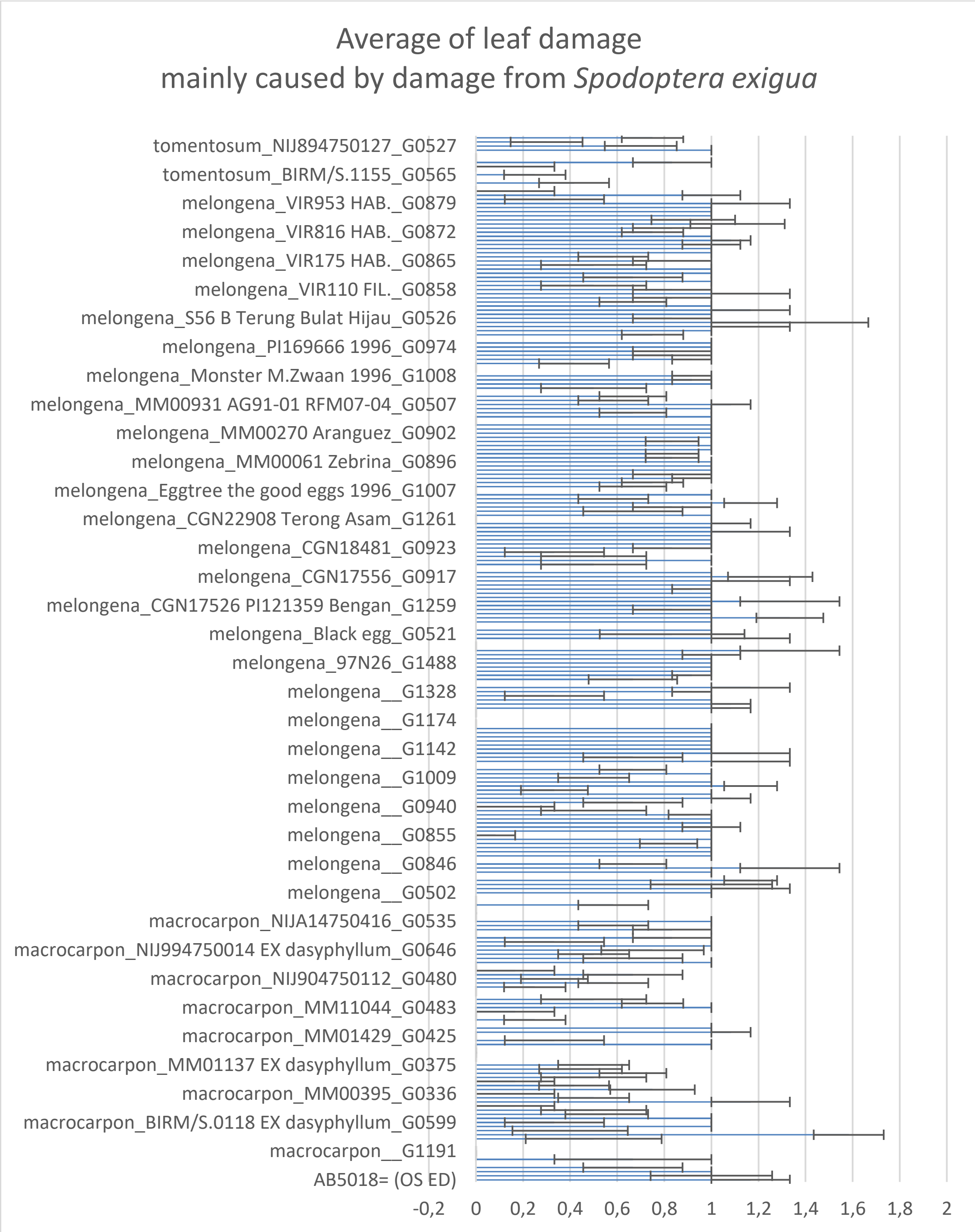
We also scored the fruits produced under *Lygus spp*. infection on plants, but it was really difficult the compare them, because the study involved different wild eggplant species that have big differances between fruit shapes and amount of fruits per plant.

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*.

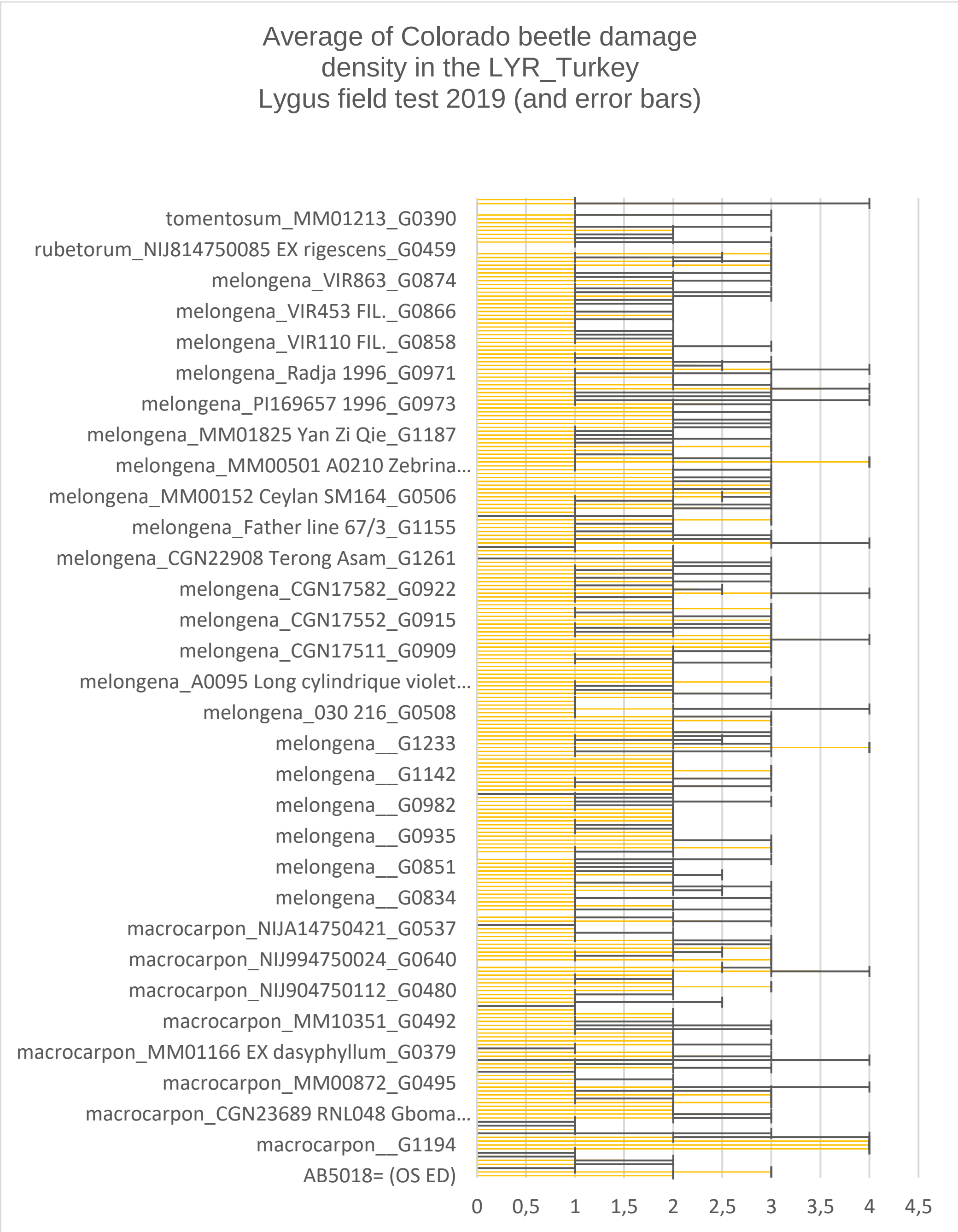


(0=R, 1=R-Ls,2=Ls,3=Ls-S, 4=S)

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.

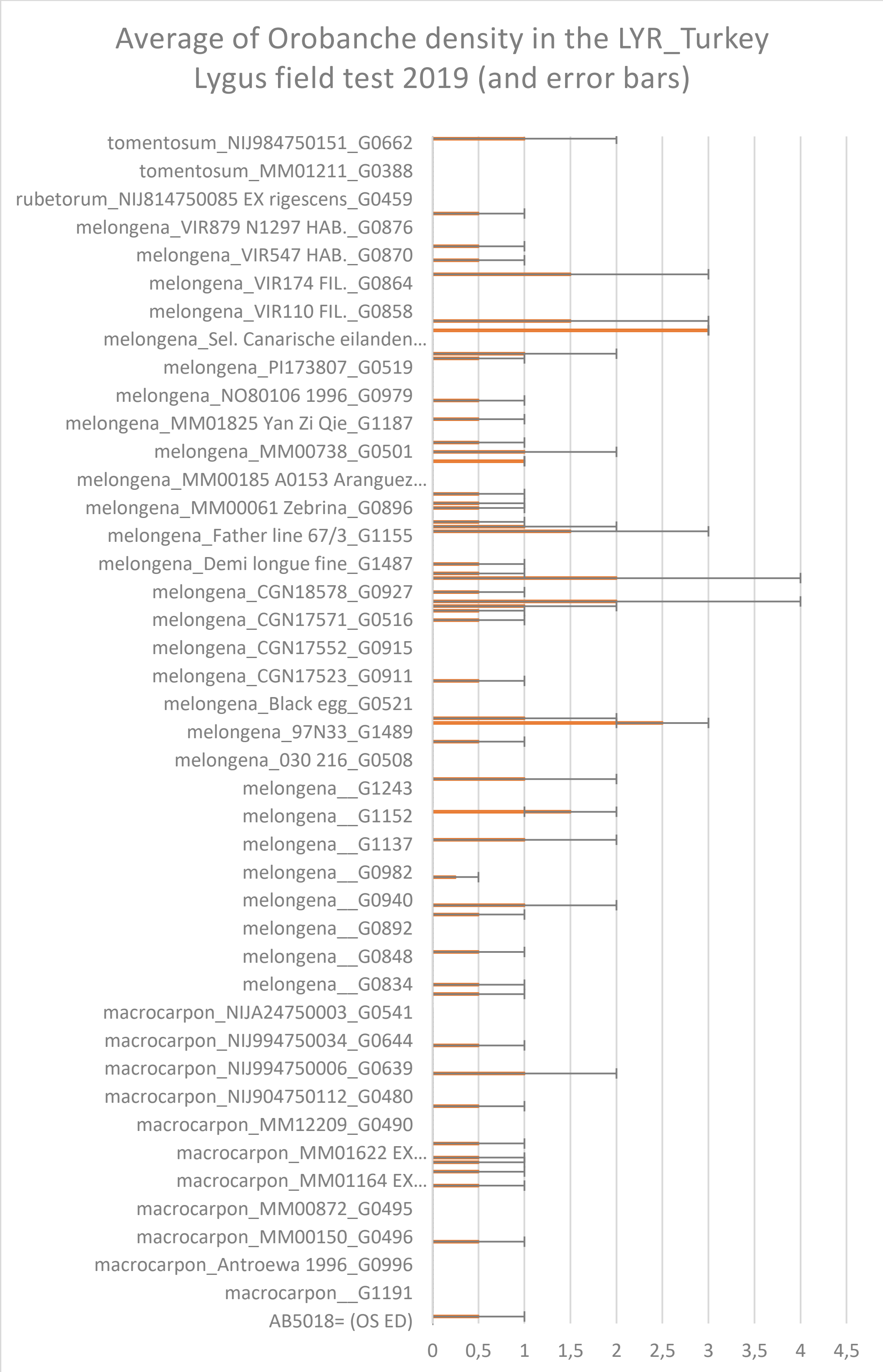
(0=R No Colorado beetle damage and, 1=R-LS, 2=LS,3=LS-S, 4=S Severe beetle feeding on the leaves and a lot of Orobanche).

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



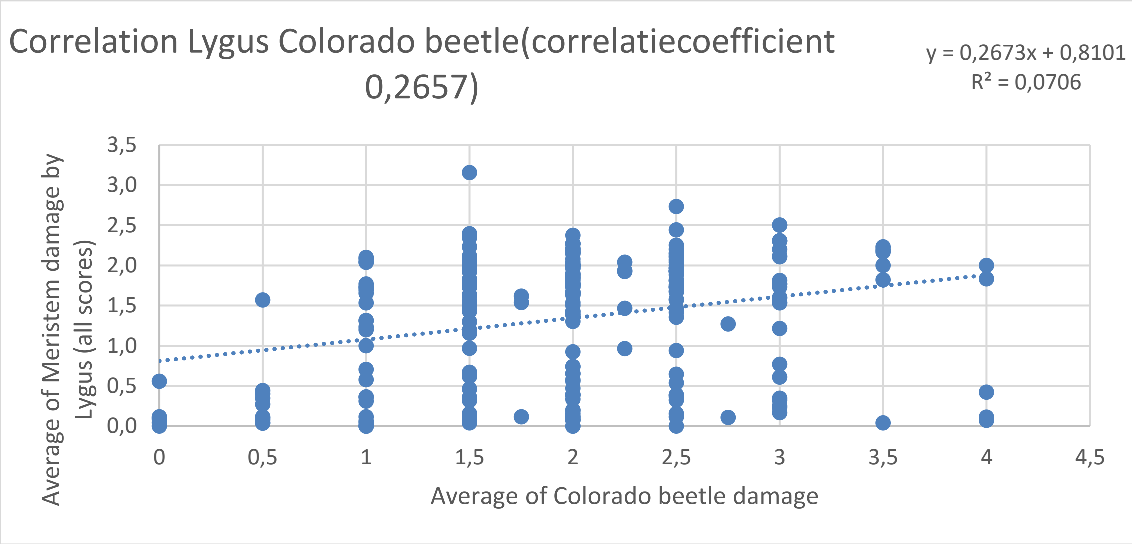
We saw that colarado beetles also feeds from orobanche leafs, and this makes our observations unclear.

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 colarado beetle score and orobanche density score in the field, because they colarado beetles also feeds from orobanches.

6. CONCLUSION

Eggplant is economically one of the most important crop from Solanacae family. It is rich in nutritions (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 pestfor eggplant production in open field. Currently, there is no efficent solution to protect the crop from this pest. Pesticides and culturel 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 mersitem 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 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 succesfully 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.

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RESUME

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