CUKUROVA UNIVERSITY
INSTITUTE OF NATURAL AND APPLIED SCIENCES

MSc. THESIS

Rochelyn DONA

EFFECT OF IRRIGATION SYSTEMS ON SOME INSECT PEST POPULATIONS ON BEAN (*Phaseolus vulgaris* L.)

DEPARTMENT OF PLANT PROTECTION

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ÇUKUROVA ÜNİVERSİTESİ
FEN BİLİMLERİ ENSTİTÜSÜ

EFFECT OF IRRIGATION SYSTEMS ON SOME INSECT PEST POPULATIONS ON BEAN (*PHASEOLUS VULGARIS* L.)

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YÜKSEK LİSANS TEZİ

BİTKİ KORUMA ANABİLİM DALI

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ABSTRACT

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In this study, the effect of three irrigation systems on the developmental of some pest populations on bean in field conditions was evaluated. In addition, temperature-dependent development and reproduction capacity of *Aphis fabae* Scopoli and *Aphis craccivora* Koch were studied in the laboratory conditions on bean (*Phaseolus vulgaris* L.) at different temperature. The aim of this work was to obtain the basic information about irrigation system selection in field areas, which play a fundamental role in IPM control strategies and emphasis was laid on common irrigation systems often applied on bean plantation. In total six insect pests were investigated which are *Frankliniella occidentalis* (Pergande) and *Thrips tabaci* Lindeman (Thysanoptera; Thripidae), *Bemisia tabaci* (Grenn) (Hemiptera; Aleyrodidae), *Aphis fabae* Scopoli (Hemiptera; Aphididae), *Tetranychus urticae* Koch (Acari: Tetranychidae), *Empoasca decipiens* Paoli (Hemiptera: Cicadellidae), *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae) and some insect predators such as *Aphidoletes aphidimyza, (Cecidomyiidae), Coccinella septempunctata (Coccinellidae)*, and *Orius* Spp *(Anthocoridae)*. According to the results, the number of *A. fabae* individual per plant from Sprinkler, drip, and furrow irrigation was 36.56, 540.95, and 10.92 adults and 42.91, 130.1, and 8.17 nymphs respectively. *T. urticae* was 15.88, 29.85 and, 6.91 eggs and 6.91, 6.36 and, 1.88 nymphs and 1.88, 3.27 and, 0.71 adults respectively. According to the predator numbers, they were more significant on drip irrigation than other systems. However, developmental period of *A. fabae* was determined at 16°C (11.58 days), 24°C (5.7 days), and at 28°C (6.62 days) compared to *A. craccivora* at 16 °C (10.5 days) and 28°C (5.0 days). The intrinsic rate of increase ($r_{m)}$ was calculated at 24°C for *A. fabae* and *A. craccivora* (0.361 and 0.352 developmental rate/days, respectively). Developmental threshold of *A. fabae* and *A. craccivora* on bean were 8.14 and 1.75°C, while thermal constant temperatures were 104.16 and 66.66 degree-days on pinto bean, respectively.

Key words: Aphid species, beneficial insects, irrigation-systems, insect pests, *Phaseolus vulgaris L.*

ÖZ

YÜKSEK LİSANS TEZİ

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Bu çalışmada, arazi koşullarında üç farklı sulama sisteminin fasulye üzerinde bulunan bazı zararlı popülasyonlarının gelişimi üzerine etkileri değerlendirilmiştir. Ayrıca, *Aphis fabae* Scopoli ve *Aphis craccivora* Koch'nın sıcaklığa bağlı gelişme ve üreme kapasiteleri, fasulye (*Phaseolus vulgaris* L.) üzerinde farklı sıcaklıklarda laboratuvar koşullarında incelenmiştir. Bu çalışmada, entegre mücadele stratejilerinde temel bir rol oynayan tarla alanlarında sulama sistemi seçimi hakkında temel bilgileri elde etmek ve genellikle fasulye ekiminde uygulanan ortak sulama sistemlerine vurgu yapılması amaçlanmıştır. *Frankliniella occidentalis* (Pergande) ve *Thrips tabaci* Lindeman (Thysanoptera: Thripidae), *Bemisia tabaci* (Grenn) (Hemiptera: Aleyrodidae), *Aphis fabae* Scopoli (Hemiptera: Aphididae), *Tetranychus urticae* Koch (Acari: Tetranychidae), *Empoasca decipiens* Paoli (Hemiptera: Cicadellidae), *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae) olmak üzere toplam yedi zararlı ve *Aphidoletes aphidimyza*, (Cecidomyiidae), *Coccinella septempunctata* (Coccinellidae) ve *Orius* Spp (Anthocoridae) gibi bazı predatör böceklerin farklı sulama sistemlerinde popülasyon yoğunlukları incelenmiştir. Sonuçlara göre, yağmurlama, damla ve karık sulama sistemlerinde bitki başına bulunan *A. fabae* ergin sayısı dokuz haftalık deneme süresinin sonunda ortalama olarak sırasıyla 36.56, 540.95, 10.92 ve nimf sayısı 42.91, 130.1, 8.17 olarak belirlenmiştir. *T. urticae*'nin farklı gelişme dönemleri sırasıyla 15.88, 29.85, 6.91 yumurta; 6.91, 6.36, 1.88 nimf ve 1.88, 3.27, 0.71 ergin olarak hesaplanmıştır. Predatör böcek sayılarına bakıldığında, damlama sulama, diğer sulama sistemlerine göre daha önemli olarak değerlendirilmiştir. Bununla birlikte, *A. fabae*'nin gelişme süresi 16°C'de 11.58 gün, 24°C'de 5.7 gün ve 28°C'de 6.62 gün; *A. craccivora*'nın gelişme süresi ise 16°C'de 10.5 gün ve 28°C'de 5.0 gün olarak belirlenmiştir. *A. fabae* ve *A. craccivora* için içsel artış hızı (rm) 24°C'de sırasıyla 0.361 ve 0.352 (gelişme hızı/gün) olarak hesaplanmıştır. Fasulye üzerinde *A. fabae* ve *A. craccivora*'nın gelişme eşikleri sırasıyla 8.14 ve 1.75°C iken, termal konstantları sırasıyla 104.16 ve 66.66 derece-gün olarak belirlenmiştir.

Anahtar kelimeler: *Aphis fabae*, damla sulama, hayat tablosu, IPM, *Phaseolus vulgaris* L.

EXTENDED SUMMARY

Nowadays, in Turkey, a lot of researches have been done in diverse fields, particularly on bean to find techniques that can be adapted for sustainable agriculture with emphasis on the ecological health and the socio-economic aspects. Abiotic and biotic factors play the most important roles in affecting field productions. For this reason, an understanding of their interactions within the environment can allow us to make better decisions about insect pest management and eventually improve the quantity and quality of yield. As an abiotic factor, the use of irrigation-systems can effect positively and negatively the field plantation. Consequently, a timely and planned irrigation system, paying attention to technical itineraries, and pest control strategies are necessary. In addition to previous studies, the current study will improve understanding and decide-making on the choice of irrigation-system on bean plantation.

The general objective of this study was to determine the effects of three irrigation systems on the evolution of some pest populations on the bean. The specific objectives were;(1) Record some insect pests at the different stages of bean for each treatment; (2) Calculate growth and development parameters of plants for each treatment; (3) Evaluate the variation a prior and posterior of irrigation sessions for each insect population; (4) Identify some insect predators into each system; (5) Calculate the average yield for fresh pods and dry grain and biomasses generated each treatment per hectare; and (6) Investigate the effect of different temperatures on the growth and development of *A. fabae* and *A. craccivora* in laboratory condition which are the most important pest on bean. The effect of three irrigation systems (sprinkler irrigation system, furrow irrigation system, and drip irrigation system) on some insect pest populations, such as *F. occidentalis*, *B. tabaci*, *A. fabae*, *T. urticae*, *E. decipiens*, *L. trifolii*, and some predators were evaluated. In the field, the experimental unit was equivalent to 9 m^2 per factor with

4 replications per irrigation system making a total of 378 m^2 with 12 parcels in 3 blocks. The experiment plan was a completely randomized block design (CRBD).

In addition, a life table of *A. fabae* and *A. craccivora* under the effect of five constant temperatures on the bean were studied in the laboratory, this study was conducted by transferring single randomly selected apterous females from the stock cage culture on to the undersurface of fabae bean leaves in the plastic Petri dishes (5cm in diameter). For each temperature level, 10 master Petri dishes as stock were placed inside each incubator. After 3 generations, 40 Petri dishes were prepared with a wetted cotton pad (0.5 cm) and placed under the leaves such that the entire cotton surface was covered to avoid them from drying. After that, 40 newborn nymphs were taken with a paintbrush carefully from the master stock to the new Petri dishes. The cotton wool in the Petri dishes was wetted daily and every 3-5 days the aphids were transferred to new bean leaf discs. The fresh leaves used were taken from bean plants in the field and brought to the Citrus Laboratory of Entomology at Çukurova University.

The experiments were conducted on five constant temperatures of 12, 16, 20, 24, and 28 ±1°C and 60±5% RH and a photoperiod of 16:00 (L:D) 24h. Forty newborn nymphs were used for each treatment. Every 24h the nymphal development was recorded until the adult stage. After the adult period, the number of newly born and survival produced by the mother were registered until the death of all adults.

The results showed that drip irrigation was not suitable for bean production in an open field. From the field experiment, it was demonstrated that drip irrigation allowed an increase of insect pest population due to the effect of weather conditions and the low quantity of water used during the growing stages of the plant. However, sprinkler and furrow irrigation in terms of yield production and increasing of insect pest populations can able to help the bean producers in the integrated control by reducing pests and allow better revenue from their field.

The yield measurable parameters for each irrigation system, such as the weight of fresh pods per plant (g) was more significant from sprinkler and furrow than drip. The number of pods per plant presented the same importance as the previous. The unfilled pods per plant only showed a high quantity for drip irrigation caused this system was severely affected than the others by the insect pest population. The number of filled pods per plant more important on sprinkler and furrow compared to drip irrigation represented to 36.24%, 41.87%, and 21.88% respectively. The average weight of 1000 grains (gram) of dry bean was significant on furrow and sprinkler compared to drip irrigation.

The average weight of 1000 filled grains (gram) was significant only on sprinkler irrigation compared to the furrow and drip irrigation. On the other hand, the number of dry grains per pod was statistically different in all the systems, but the most important of them was sprinkler irrigation. The mean dry grain per ton/ha from different irrigation systems, furrow 0.88 t/ha slightly similar to sprinkler 1.096 t/ha and significantly different to drip irrigation to 0.33 t/ha. The mean of fresh bean pod sprinkler and furrow was almost the same at 10.55 and 9.98 t/ha respectively to compared drip irrigation to 5.77 t/ha. This kind of decreasing was relatively due to the infestations by the insect pest populations in interaction with the abiotic factor.

Irrigation systems, in the field experiment *A. fabae* adult and nymph stages on the effect of sprinkler, drip, and furrow irrigation showed that it exists a significant difference between drip compared to sprinkler and furrow irrigation referring at the adult and nymph numbers population per plant that represented in percentage, 91.95%, 6.20%, and1.84% and nymphal stages, 71.82%, 23.67%, and 4.50% respectively.

The fluctuation of the temperature by interacting with the system irrigation during nine weeks was showed two peaks for both developmental stages. They have started on May 14th and decreased on May 21st. After that, the highest peak showed on June 18th for both. But, these variations have been due to the effects of temperature and humidity of the environment during this period.

The developmental time of *A. fabae* and *A. Craccivora* under the effect at five constant temperature at five temperatures regimes, 65±5% RH, and a photoperiod of 16:00 (L:D) 24h in the laboratory condition were showed, from the first instar to the adult stage, the developmental period of times per decreased with diminution of constant temperature, but inversely increased such as the total developmental time (TDT) of *A. Fabae* has been resulted from the lowest at 24 and 28°C (5.7 and 6.62days) to the highest at 12 and 16°C (11.58 and 16.56 days) respectively, the death ratio (%) at 12°C ((0%) the lowest did not present any death case, while increased with highest at 28°C (25%).

The intrinsic rate increase (rm) was more significant at 20°C (0.35) and 24°C (0.36) aphid/aphid/day on the bean leaf. The oviposition (day) showed a significant decrease with the augmentation of the thermal constant from the highest 28°C (6.67 days) to the lowest 12°C (23.95 days). The developmental time of *A.craccivora* decreased by increasing the temperature until the highest temperature in this study showed at 28°C (5.0 days) and the lowest 16°C (10.6 days). The death ratio (%) showed at 16°C (20%), 24°C (5%), and 28°C (20%), those increase death ration at the low and high should be clearly demonstrated that the biology of this aphid doesn't require the low and high degree of temperature, but an optimal temperature around 24°C.

The generation time decreased with the increasing the temperature regimes at 28°C (10.19 days) inversely increased at 16°C (22.28 days). The intrinsic rate increase (rm) was at 28°C (0.36) and the low 16°C (0.177 aphid/aphid per day). The oviposition day of this pest decreased with increasing the temperature. But, inversely augmented.

GENİŞLETİLMİŞ ÖZET

Günümüzde Türkiye'de, çeşitli alanlarda, özellikle ekolojik, sağlık ve sosyo-ekonomik yönler vurgulanarak sürdürülebilir tarıma uyarlanabilecek teknikler bulmak için fasulye üzerine birçok araştırma yapılmıştır. Abiyotik ve biyotik faktörler, bitki üretimi ve kalitesi üzerinde en önemli rolü oynar. Bu nedenle, çevre içindeki etkileşimlerinin anlaşılması, zararlılarla mücadele hakkında daha iyi kararlar almamıza ve sonuç olarak ürün miktarını ve kalitesini artırmamıza yardımcı olabilecektir. Abiyotik bir faktör olarak, farklı sulama sistemlerinin kullanılması tarım ürünlerini olumlu ve olumsuz olarak etkileyebilir. Sonuçta, teknik olarak kullanılan yöntemlere ve zararlılarla mücadele stratejilerine dikkat eden, zamanında ve planlı bir sulama sistemi gereklidir. Önceki çalışmalara ek olarak, mevcut durum, fasulye ekiminde sulama sistemi seçimine ilişkin anlayışı ve karar vermeyi geliştirecektir.

Bu çalışmanın genel amacı doğrultusunda, üç sulama sisteminin fasulye üzerindeki bazı zararlı popülasyonları üzerine etkileri belirlenmiştir. Amaçlar doğrultusunda: (1) Her işlem için fasulyenin farklı gelişme aşamalarında bazı böcek zararlıları kaydedilmiş; (2) Her işlem için bitkilerin büyüme ve gelişme parametreleri hesaplanmış; (3) Her böcek popülasyonu için sulama zamanlarının öncesi ve sonrasındaki çeşitlilik ve değişkenlik değerlendirilmiş; (4) Her sistemde bazı böcek avcıları tanımlanmış; (5) Hektar başına her işlemden sonra oluşan taze fasulye, kuru ağırlık ve biyokütle için ortalama verimi hesaplanmış; ve (6) farklı sıcaklıkların, laboratuvar koşullarında fasulye üzerindeki en önemli zararlılar olan A. fabae ve A. craccivora'nın büyümesi ve gelişimi üzerindeki etkisi araştırılmıştır. Üç sulama sisteminin (yağmurlama sulama sistemi, karık sulama sistemi ve damla sulama sistemi) *F. Occidentalis*, *Thrips tabaci* , *B. tabaci*, *A. fabae*, *T. urticae*, *E. decipiens*, *L. trifolii* gibi bazı zararlı böcek popülasyonları ve bazı avcılar üzerindeki etkisi değerlendirilmiştir. Arazide deneme alanı, sulama sistemi başına 4 tekerrürlü ve her tekerrür 9 m^2'ye eşdeğer olup, 3 blokta 12 parsel olmak üzere toplam 378 m^2 olarak planlanmıştır. Deneme tesadüf blokları deneme desenine göre kurulmuştur.

Ayrıca beş sabit sıcaklığın fasulye yaprağı üzerinde bulunan *A. fabae* ve *A. craccivora*'ya etkisi değerlendirilmiş ve yaşam tabloları laboratuvarda incelenmiştir. Bu çalışma stok kafes kültüründen rastgele seçilmiş kanatsız dişilerin plastik Petri kaplarına (5 cm çapında) fasulye yapraklarının alt yüzeyine aktarılmasıyla gerçekleştirilmiştir. Her sıcaklık seviyesi için, her inkübatörün içine stok olarak 10 ana Petri kabı yerleştirilmiştir. 3 nesil sonra, 40 Petri kabı ıslatılmış bir pamuklu ped (0.5 cm) ile hazırlanmış ve kurumasını önlemek için tüm pamuk yüzeyi kaplanacak şekilde yaprakların altına yerleştirilmiştir. Daha sonra, ana stoktan yeni Petri kaplarına bir boya fırçası ile 40 adet yeni doğmuş nimf dikkatlice alınmıştır. Petri kaplarındakı pamuk her gün ıslatılmış ve her 3-5 günde bir yaprak bitleri yeni fasulye yaprak disklerine aktarılmıştır. Kullanılan taze yapraklar tarladaki fasulye bitkilerinden alınarak Çukurova Üniversitesi Bitki Koruma Bölümü Turunçgil Zararlıları Laboratuvarı'na getirilmiştir.

Denemeler; 12, 16, 20, 24 ve 28 ± 1°C sıcaklıklarda, %60±5 RH'lik bağıl nemde ve 16:8 (L:D) 24 saatlik bir fotoperiyotta gerçekleştirilmiştir. Her sıcaklık için kırk yeni doğan nimf kullanılmıştır. Nimf gelişimi ergin aşamasına kadar her 24 saatte bir kaydedilmiştir. Ergin döneminden sonra, yeni doğan nimf ve canlı kalan erginlerin sayısı, tüm erginlerin ölümüne kadar kaydedilmiştir.

Sonuçlar damla sulamanın açık tarlada fasulye yetiştiriciliğine uygun olmadığını göstermiştir. Arazi denemesinde, hava koşullarının etkisi ve bitkinin büyüme aşamalarında kullanılan düşük su miktarı nedeniyle, damla sulamanın zararlı böcek popülasyonunu artırdığı tespit edilmiştir. Bununla birlikte, ürün verimi ve zararlı popülasyonlarının artması açısından yağmurlama ve karık sulama, zararlıları azaltarak fasulye üreticilerine entegre mücadele programında yardımcı olabileceği ve daha fazla ürün elde edilmesini sağlayabileceği tespit edilmiştir.

Bitki başına taze fasulye ağırlığı (gram) gibi her sulama sistemi için verim ölçme parametreleri, karık sulama sisteminde, yağmurlama ve damla sulama sisteminden daha önemli olarak bulunmuştur. Bitki başına fasulye kapsüllerinin dolmamış bölmeleri, yalnızca damla sulama için yüksek bir miktar göstermiştir ve damla sulama sisteminin zararlı böcek popülasyonlarından diğerlerine göre ciddi şekilde etkilenmesinden kaynaklı olacağı düşünülmüştür. Bitki başına dolan fasulye kapsülü sayısı, damla sulamaya kıyasla yağmurlama ve karık sulama sisteminde, sırasıyla %36,24, %41.87 ve %21.88'dir ve daha önemli olarak bulunmuştur. Ortalama 1000 tane (gram) kuru fasulye ağırlığı, damla sulamaya göre karık ve yağmurlama sulama sisteminde daha önemli olduğu tespit edilmiştir. Ortalama 1000 tane dolu kuru fasulye ağırlığı ağırlığı (gram), karık ve damla sulamaya kıyasla sadece yağmurlama sulama sistemi için önemli olarak bulunmuştur. Diğer taraftan fasulye kapsülü başına düşen kuru dane sayısı tüm sistemlerde istatistiksel olarak farklı olarak bulunmuştur ancak en önemlisi yağmurlama sulama sistemi olarak belirlenmiştir.

Farklı sulama sistemlerinde hektarbaşına ortalama kuru fasulye ağırlığı en önemli karık sulamada belirlenmiş, karık sulamada 0.88 t/ha, yağmurlama sulamada 1.096 t/ha ve damla sulamada 0.33 t/ha olarak tespit edilmiştir. Taze fasulye kapsülü ağırlığı yağmurlama ve karık sulama sistemi için sırasıyla 10,55 ve 9,98 ile hemen hemen aynı olarak bulunmuş,damla sulamada ise 5,77 t/ha verim oranı ile diğerlerinden düşük olarak belirlenmiştir. Abiyotik faktör ile etkileşim halindeki zararlı böcek popülasyonlarında bir azalma olduğu gözlemlenmiştir. Dokuz haftalık takip periyodunda sıcaklığın dalgalanması ile birlikte her bir sulama sisteminde zararlı popülasyonlarında iki tepe noktası görülmüştür.İlk tepe noktası 14 Mayıs'ta gözlenmiş ve 21 Mayıs'ta popülasyon azalma eğilimine girmiştir. Bu noktadan sonra haftalık olarak en yüksek popülasyon 18 Haziran' da gözlenmiştir. Bu farklılıkların, arazide yapılan takip periyodu içerisinde ortamın sıcaklık ve neminin zararlı popülasyonlarının gelişimi için uygun olduğundan kaynaklanmıştır.

Yağmurlama, damla ve karık sulama sistemlerinin fasulye bitkisinde gözlenen *Aphidoletes aphidimyza*, (Cecidomyiidae) *C. septempunctata*

(Coccinellidae) ve *Orius* spp. (Anthocoridae) gibi yırtıcı böcek popülasyonlarının gelişimi üzerine sadece damla sulama sisteminde önemli farklılıklar gözlemlenmiştir. Bu farklılığın, damla sulama sisteminde zararlı popülasyonunun yüksek miktarda bulunmasından kaynaklı olduğu tespit edilmiştir.

Aphis fabae ve *A. craccivora*'nın laboratuvar koşullarında beş farklı sıcaklıkta, % 65 ± 5 bağıl nemde, 16:8 (L:D) saatlik bir fotoperiyotta gelişim süresi, ergin evresinin ilk aşamasında, sabit sıcaklığın azalmasıyla birlikte gelişme süresinin azaldığı, ancak A. fabae'nin toplam gelişimsel (TDT) süresinin ters orantılı olarak arttığı, 24 ve 28°C'de en yüksek (5.7 ve 6.6 gün) ile 12 ve 16°C'de (11.58 ve 16.56 gün), en düşük ölüm oranı (%) 12°C'de (% 0) herhangi bir ölüm görülmezken, en yüksek ölüm oranı (% 25) 28 °C'degörülmüştür.

Yavru üretimi, sıcaklıkta bir düşüşle birlikte bir azalma göstermiştir, 24°C'de (4.84 gün) ise sıcaklığının eşik seviyesine ulaşana kadar ve düştükten sonra arttı. Örneğin, maksimum sıcaklık 28°C'de (2.08 gün) gösterildi. İç hız artışı (rm) fasulye yaprağında, 20°C'de0.35 ve 24°C'de0.36 yaprak biti/gün ile diğer sıcaklıklara göre daha belirgin bir fark göstermiştir. Yumurta vermeye başlama zamanında (gün), termal sabitin artmasıyla birlikte önemli bir düşüş gözlenmiş ve en yüksek 28°C'den (6.67 gün) en düşük 12°C'ye (23.95 gün) indiği gözlemlenmiştir

Aphis craccivora'nın gelişme süresi, sıcaklığın artmasıyla birlikte azalmış, 28°C'de 6.67 gün ve 16°C'de 10.6 gün olarak hesaplanmıştır. Ölüm oranları (%), 16°C'de % 20, 24°C'de % 5 ve 28 °C'de %20 olarak belirlenmiştir.Düşük ve yüksek ölüm oranlarının açıklanabilmesi için *A. craccivora*'nın biyolojisinin açık bir şekilde gösterilmesi gerekmektedir. *A. craccivora*'nın düşük ve yüksek sıcaklık derecesine ihtiyaç duymadığı, optimal gelişme sıcaklığının ise 24°C civarında olduğu belirlenmiştir.

Nimf sayısı 24°C'de günde 6,53 yaprak biti kaydedilmiştir. 16°C'lik en düşük sıcaklıkta günde 3,59 yaprak biti, 28°C'de günde 4,14 yaprak biti olarak belirlenmiştir. Sıcaklık artışı ile birlikte 24°C'ye kadar artış gözlenmiş, en yüksek sıcaklıkta ise sayının azaldığı görülmüştür. Fasulye yaprağında bu zararlının optimum gelişimi için 24°C'nin en iyi sıcaklık olduğu belirlenmiştir. Bir döl süresi sıcaklığın artmasıyla birlikte azalmış, 28°C'de 10.19 gün ve 16°C'de 22.28 gün olarak hesaplanmıştır.İç hız artışı (rm) 28°C'de 0.36 gün/yaprak biti ve en düşük sıcaklık 16°C'de 0.177 gün/yaprak biti olarak belirlenmiştir. Bu zararlının nimf vermeye başladığı süre sıcaklık artışıyla birlikte azalmıştır.

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LISTE OF ABBREVIATIONS

ANOVA	: Analysis of Variance
BCMV	: Bean common mosaic virus
CRBD	: Randomized Complete Block Design
CT	: Conventional
DI	: deficit irrigation
FAO	: Food and Agriculture Organization
G	: gram
GLM	: General Linear Models
FI	: full irrigation
IPM	: Integrated Pest Management
LAI	: Leaf Area Index
Lx	: Age-specific number of female offspring
LMF	: Liriomyza leaf miner flies
Kg	: Kilogram
mx=	: Fecundity
lx	: Age-specific survival rate
Nbr	: Number
PC	: Principal Component
Ro	: Net reproduction
r =	: Intrinsic Rate of Increase,
SPSS	: Statistical Package for the Social Sciences
ST	: Strip tillage
TDT	: Total Developmental Time
T/ha	: Ton per hectare
To	: Number of generation
Var	: variety
x =	: Age in days

XXIX

1. INTRODUCTION

Pinto bean (*Phaseolus vulgaris* L.) is one of the important vegetable and its cultivation extended in the tropical and sub-tropical areas of the world including Turkey. With the augmentation demographic of the living-being in this planet and increased demand for vegetables by the ever exploding population, greater emphasis for maximizing the productivity of pinto bean laid in recent years, because, in general, legumes are sources of complex carbohydrates, protein, and dietary fiber. They also provide micronutrients, vitamins, carotenoids, and phenolic compounds. Protein content of legumes ranges from 17 to 40% and carbohydrate content is around 55-60% (Akillioglu and Karakaya, 2010; Chauhan and Abhishek, 2016). In Adana, it is grown in open field for supply of fresh tender pods for the consummation. Among the limiting factors from abiotic and biotic, such as temperature, humidity, and insect pests are the most effective in agricultural crops all over the world.

Dry bean (*Phaseolus vulgaris* L.), also known as common bean, is the most important food legume in the world (Urrea et al., 2009). Turkey ranks in the top 25 countries in terms of dry bean production with 235,000 tonnes (FAOSTAT, 2018). South-Eastern Anatolia and Samsun-Tokat-Amasya are micro gene centres for beans (Şehirali et al., 2005).It is of economical and nutritional importance, and major production are from regions of the north of Bursa (6109 tons) and Samsun provinces (5061 tons) while that of Adana is significantly less. For the Turkish farmers, the common beans are still important genetic resources that are directly used by farmers on a small scale (Balkaya et al., 1999). Farmers have maintained local populations and exchanged seeds with their environments, principally in local markets. The consumers tend to consume green beans as dry seed. However, fresh seed consumption is possible in some rural parts of Turkey. According to FAO (2016) green bean production per in millions of tons is dominated by China (18.7), Indonesia (0.9), Turkey (0.7) and India (0.7).

Even with the incredible expansion and success of *Phaseolus* beans worldwide, a wide range of challenges to their cultivation exist. Common beans are vulnerable to drought and heat, which are likely to be exacerbated by climate change (Beebe et al., 2012; Jarvis et al., 2012). Major diseases for the crop include root rot, *Xanthomonas* blight, downy mildew, rust, angular leaf spot, anthracnose, web blight, white mold, halo blight, *Bean common mosaic virus* (BCMV), and a variety of other viruses. Major insect pests include Aphids, red spider, mealybug, whitefly, leafhoppers, weevils, various caterpillars, flea beetles and Mexican bean beetles etc. (Beebe et al., 2012).

In Turkey Pinto bean usually infested by different pests that cause considerable damage in both quantity and quality of pods in terms of yield, Aphids, leaf miner, leafhoppers, whitefly, Thrips and red spider mite cause serious damage to plant and subsequently yield (Hilje and Stansly, 2001; Musa and Ren, 2005; Najafabadi et al., 2011; Aydemir and Toros, 1990). This study aimed to evaluate the population fluctuations of the main pests infesting pinto beans (*Phaseolus vulgaris* L.). And also study the combined effects of three irrigation systems on tested pests and utilize the obtained results in developing the integrated pest management (IPM) programs against these pests on pinto bean plants through the effect of twice, sprinkler, furrow and drip irrigation on these pests (McEwen, 1981.)

Insects are cold-blooded organisms and the temperature of their bodies is approximately the same as that of the environment. Therefore, abiotic factors such as temperature, humidity and rain are probably the most important environmental factors influencing insect behavior, such as distribution, development, survival, and reproduction where the food is available. In the agriculture system the human being cannot influence strongly surrounding the temperature in the field or rain. But we can influence microclimate in the pest populatıon niches. For this reason, the irrigation systems are being able to impact the insect population and fıeld production.

Three hypotheses were formulated as following; H0- The sprinkler irrigation could able to significantly increase some pest populations; H1- The drip irrigation could generate more pest populations than other systems; and H2- One of the systems could help in the implementation of integrated pest management (IPM). The general objective was to determine the effect of irrigation systems on some insect pest populations on bean field. More specifically, (1)- Record some insect pests at the different stages of bean for each treatment; (2)- Calculate growth and development parameters of plants for each treatment; (3)- Evaluate the variation a prior and posterior of irrigation sessions for each insect population (4)- Identify some insect predators in each system; (5)- Calculate the average yield for fresh pods and dry grain and biomasses generated in each treatment per hectare; (6)- Record the effect of temperatures regimes on growth and development of *A. fabae* Scopoli and *A. craccivora* Koch which are important pests at the bean cultivation in the laboratory conditions.

2. LITERATURE REVIEW

With globalization, demographic shift and climate change are increasing, and the insect populations are simultaneously growing at the same rhythm. The majority of plants used in the ecosystem have been genetically modified and imported from other locations, consequently active and passive invasive migration of pests from a region to another one, and a country to other is now common. From those, few are dangerous to plants and most are annoying. The abiotic and biotic factors that have influenced these insects throughout their life cycle can affect them both positively and negatively. For example, climate change is ideal for a variety of insects, so learning how to control them is imminent. The eradication of the pests is not ideal because they have their place in the ecosystem. Understanding and using appropriate control measures can make things easier. Below are some studies that show insect pest management and recommendations;

2.1. Irrigation System

Dapaah et al., (2000). Indicated that influence of sowing date and irrigation on the growth and yield of pinto beans (*P. vulgaris* L.) in sub-humid temperate environment. The field experiments were conducted during the 1994/1995 and 1995/1996 seasons at Lincoln University, Canterbury, New Zealand to examine the influence of sowing date and irrigation on the growth and yield of pinto bean. The mid- to late November-sown crops yielded more than the late October to early November and December-sown crops because the leaf area of the former increased most rapidly, achieved a higher maximum LAI and LAD and consequently intercepted more photosynthetically active radiation(PAR). They also had faster pod growth rates and 26 % of stored assimilates contributed to pod growth compared with 13 % in late October to early November and 5 % in December-sown crops. The results showed that pinto beans can grow and yield well in

Canterbury, and that a yield advantage could be obtained when sown in mid- to late November and with irrigation.

Sezen et al., (2008). The effects of different irrigation regimes on yield and quality of green beans (*Phaselous vulgaris* L.) irrigated with a drip irrigation system under field conditions in the Mediterranean region of Turkey were evaluated along two years. Irrigation regimes consisted of four irrigation intervals based on four levels of cumulative pan evaporation (Epan) values (I1: 15; I2: 30; I3: 45 and I4: 60 mm); irrigations occurred on the respective treatments when Epan reached target values, and three plant–pan coefficients as for irrigation levels (Kcp1 = 0.50, Kcp2 = 0.75 and Kcp3 = 1.00).

Chavoshi et al., (2018), this field experiment was executed as the split plot in a randomized complete block design with three replications in 2014. In a red bean irrigated farm, halt irrigation was implemented in main plots and the treatments included the control (full irrigation) and halt irrigation at vegetation, flowering, and pod development stages. In subplots utilization of bio-fertilizers were applied at four cases of control, phosphorus solubilizing bacteria, potassium solubilizing bacteria, and combined application of these bacteria in soil. Results showed that halt irrigation and bio-fertilizers had significant interaction on red bean biomass.

Boydston et al., (2018). The goal of this study was to evaluate the response of eight pinto bean cultivars to deficit irrigation when grown under conventional (CT) vs strip tillage (ST). Drought was imposed to one half of the plots approximately 30 days after emergence by reducing irrigation by 48% [deficit irrigation (DI)] compared to full replacement of estimated evapotranspiration (FI = full irrigation). DI reduced bean seed yields by 48 and 46% in 2015 and 2016, respectively.

2.2. Pest of Bean

Altieri et al., (1977).Weeds are major components of agro-ecosystems and they affect the biology of pests and beneficial insects in several ways; provision of flowers, presence of neutral insects, modification of crop microclimate, production of chemical stimulus, alteration of colonization background, etc. The more relevant beneficial crop–weed–insect interactions are discussed. The role of weeds in regulating pest populations is illustrated by studies on bean (*P. vulgaris* L.) cropping systems, in which chemical interactions between *Empoasca kraemeri* Ross & Moore and two grass weeds were identified. It is proposed to continue and develop this kind of research in order to incorporate weeds into pest control strategies.

Sexana, (1999). The western flower Thrips, *F. occidentalis* (Thysanoptera: Thripidae) is one of the most serious of pests, and listed as a major insect pest in the Mediterranean region Yield losses due to bean flower Thrips to grain legumes ranges from 20 –100% in Africa. This Thrips is considered as a critical constraint to grain legume productivity and it causes leaf drying, flower shedding, low pod set and malformed pods.

Blackman and Eastop, (2000) *A. fabae* (Hemiptera: Aphididae) is a polyphagous cosmopolitan pest and one of the best-known pests of agricultural eco-systems, causing damage to horticultural plants.

Oljaca et al., (2000). A field study was conducted on an experimental field, and, the objective of this study was to find the optimal spatial arrangement of a maize–beans intercrop in irrigated and rained farming systems. Plant arrangement patterns in an intercropping system did not significantly affect Leaf Area Index (LAI) values in maize compared with a sole crop, while irrigation had a greater positive influence on it. Leaf area values of beans were more sensitive to the same treatments. Micro environmental conditions in maize–bean mixtures were more favorable for bean crop than for sole beans.

Hilje et al., (2001). Whiteflies (*Bemisia* spp.) and the viruses they vector cause extensive losses to many horticultural and agronomic crops throughout the tropics and subtropics. These losses have spurred a worldwide search for cost-effective management strategies. Cultural practices can play a significant role in integrated pest management (IPM) systems targeting whiteflies, because of their preventative nature

Nachman and Zemek, (2002) *T. urticae* feeds on leaves causing damage to chlorophyll and thereafter serious loss of yield. It is regarded as the most important pest species for cultivated crops worldwide as well as in Turkey.

Aslan et al., (2004). The cotton whitefly, *B. tabaci* (Gennadius) (Hemiptera: Aleyrodidae) damages many economically important agricultural crops around the world. *B. tabaci* causes direct and indirect damage by sucking sap, virus transmission and producing honeydew that leads to rapid growth of sooty mould.

Balkaya and Ergün, (2007). Species belonging to the family Leguminosae are widely grown in Turkey. Pinto bean (*Phaseolus vulgaris* L. var. Pinto) is a tradition al crop in Turkey and farmers grow local varieties that they select and maintain. Pinto bean is an important food in Samsun province, Turkey. Its crop is consumed as fresh pods, and fresh pod seed or dry seeds. This study was conducted in order to select valuable genetic resources of the pinto bean (*Phaseolus vulgaris* L. var. Pinto) under the ecological conditions of Samsun in 2003and 2004. In the first year, 44 pinto bean populations were collected and evaluated according to their morphological, earliness, and yield traits. The results showed that populations were significantly different in pod length, width, longitudinal section shape, shell thickness, color, suture string, and curvature. From the observations, 10 genotypes were evaluated as superior using a weight-based ranking method for fresh pod and fresh grain pod in the first year of the study. In the second year, from these selected genotypes4 genotypes (55ÇA07, 55ÇA15, 55TE15, and 55TE20) for fresh pods and 5 genotypes (55ÇA01, 55ÇA05, 55ÇA15, 55ÇA24, and55TE15) for fresh grain pods were determined as promising genotypes. At the end of this research, selected genotypes will be used in the development of new promising pinto bean varieties.

Balkaya and Ergün, (2008), in the north of Turkey, pinto bean *(P. vulgaris)* is one of the most important crops. Forty-four analyzed populations of pinto bean were collected from Samsun province in northern Turkey. The variability of the 44 self-pollinated populations of pinto bean was evaluated on morphological, reproductive, and agronomical traits during 2003-2004. Individual data for 24 traits (14 quantitative and 10 qualitative) related to earliness and yield, and plant, pod, and seed structure were analyzed using Principal Component (PC) analysis which revealed differences among the populations.

Najafabadi et al., (2011). The impact of nitrogen fertilization on bean plants (Phaseolus vulgaris L.) and T. urticae population dynamics were investigated in the field at Khomein, Markazi Province, Iran, during 2008-2010. In this study, six bean cultivars (Chiti beans: Khomein and Ks21189, Red beans: Akhtar and Ks31169 and White beans: Pak andG11867), with five nitrogen levels (0, 11.5, 23, 46 and 69 kg ha G N as Urea 46% N), were evaluated in a factorial1experiment based on randomized complete blocks design with four replications. Results of analysis of variance for numbers of adult or immature stages of *T. urticae* were showed that significant variations were observed both among nitrogen treatments and among six bean cultivars, in each year.

Rubiales and Mikic, (2015), Legumes in Sustainable Agriculture in the World population is predicted to double by 2050 imposing an increasing demand for food that comes together with an increasing concern on environment and food security. Under this pressing scenario for agriculture, the widely acknowledged beneficial role of legumes in cropping systems, by increasing biological nitrogen fixation, reducing energy costs, improving soil physical conditions and biodiversity.

Mahmoud et al. (2017) Effect of Temperature, Relative Humidity and Natural Enemies on some Insect Pests Infesting Faba Bean Plants at El-Monofia Governorate. The results were indicated that the population fluctuation of *Aphis craccivora* Koch and the Thrips tabaci were higher during (2012-2013 season) than the second season (2013-2014). The statistical analysis of simple correlation and partial regression showed that a positive significant relationship between the daily mean of temperature and relative humidity and *Aphis craccivora* population in the two successive seasons (2012-2013 and 2013-2014). The relationship between the predators Green lacewing *Chrysoperla carnea* (Steph), Hover fly Metasyrphus Corrollae and the pest population were negative significant.

Safe, et al., (2018). The objectives of this study were to find the correlation between population dynamics of the whitefly, *B. tabaci*, *P. vulgaris* cultivars, temperature and humidity during the summer and winter growing seasons of 2013 and 2014. The three *P. vulgaris* cultivars screened were Copy, Polesta and Manga. In 2013 and 2014 cropping seasons, the population densities of *B. tabaci* gradually increased from the 3rd week of March until the 4th week of April. For, the population density increased and reached a peak from the 1st week of May, and then the population density decreased gradually from the 4th week of May until the 3rd week of June in 2013 and 1st of June in 2014.

Gathage, (2018). Liriomyza leaf miner species are exotic pests of horticultural crops in Africa. The most economically important species include *L. sativae* (Blanchard), *L. trifolii* (Burgess) and *L. huidobrensis* (Blanchard) (Diptera: Agromyzidae) which are major pests of many vegetables and ornamental crops worldwide. In Kenya, production of horticultural crops is severely constrained by infestation of Liriomyza leaf miner flies (LMF). As a result, farmers increasingly use synthetic chemical insecticides and spray more frequently in response to damage by key pests such as LMF which has led to development of pests' resistance to synthetic pesticides, elimination of natural enemies, environmental contamination, and health risks due to pesticide responses.

Ekram et al., (2019). The results recorded the major pests during two successive summer plantation 2017 and 2018. The highest total number recorded by *Aphis craccivora* Koch (Hemiptera: Aphididae) exhibited 1100.33 individuals/25leaves and the lowest total number recorded by *Ophiomyia Phaseolus* (Tryon) (Diptera: Agromyzidae) as 64.33 individuals/25 leaves during summer season 2017 and 2018, respectively. The highest total number recorded during spring seasons during both2017 and 2018, represented by *A. craccivora* being 1125.63 individuals/25 leaves and the lowest number of O. phaseolus being 74.00 individuals/25 leaves and the results noticed no significant difference between the two seasons. The results indicated that 12 species of predators belonging to eleven families were recorded. While the recorded parasitoids were 12 species in five families. The present work here recorded the highest mean number of total mines (occupied and empty) caused by *Liriomyza trifolii (*Burgess) (Diptera: Agromyzidae) larvae were significantly represented higher in summer plantation (March) during 2017 and 2018 represented by 21.95and18.31individuals/25 leaves, respectively. The parasitoids were recorded parasitized the leaf miners were *Opius dissitus* (Muesebeck) (Hymenoptera: Braconidae), *Diglyphus isaea* (Walker) (Hymenoptera: Eulophidae) and *Halticoptera* sp. (Hymenoptera: Pteromalidae). Also the percentage of parasitism of aforementioned parasitoids was studied.

3. MATERIALS AND METHODS

3.1. Field Works

3.1.1. Preparation of the Field.

This study was conducted on field of Plants Protection Department at Cukurova University in Adana in from 4th April as sowing date to 10th July 2020 of harvest time. This study is designed precisely in the context of researches about some resolutions for the multiple problems which are caused by some insect pest populations on bean (*Phaseolus. vulgaris* L.) by involving three irrigation-systems such as sprinkler, furrow, and drip irrigation system as main factors that able to impact of *F. occidentalis*, *B. tabaci*, *A. fabae*, *A. craccivora*, *T. urticae*, *E. decipiens*, and *Liriomyza* sp. populations and also on predators that can able to affect them. The field experiment was equivalent to 18 m^2 per unity per factor with 4 repetitions each. (Table 3.1; Fig 3.1). With regard to the experimental units in field, the experimental procedures were as follows.

Table 3.1. Repartition and description of the experiment design.

Irrigation systems	Irrigation's time	Surface/square meter/ parcel	Nb row /parcel	Nbr of plant / row	Nbr of reed/row	Nbr Plant/ p	Nbr reed/ p
Furrow-irrigation	**2h/week**	**18 (6x 3)**	**4**	**24**	**12**	**96**	**48**
Drip-irrigation	**2h/week**	**18 (6x 3)**	**4**	**24**	**12**	**96**	**48**
Sprinkler-irrigation	**2h/week**	**18 (6x 3)**	**4**	**24**	**12**	**96**	**48**

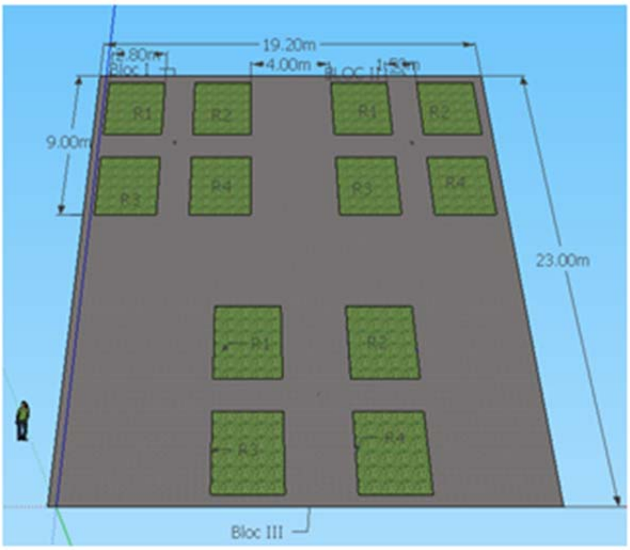


Figure 3.1. Field layout and Experimental design (Completely Randomized Block Design, (CRBD)

Each parcel measures 6 m x 3 m giving a surface area of 18 m^2. The experimental units were separated with 1.5 m gap and a 5 m distance between the irrigation systems. (Figure 3.2)

Figure 3.2. Parcel and block delimitation in the experimental site

The ridges were prepared with a tractor. There were 4 rows of ridge each measuring 6 m x 0.3 m and each separated by 1 m. (Figure 3.3)

Figure 3.3. Preparation of ridges

Two seeds were planted per hole at a depth of 3 cm in the morning. After planting, all plots were irrigated by sprinkler irrigation (Figure 3.4)

Figure 3.4. Planting activities.a) sowing two seeds per hole, b) one week after plantation with sprinkler irrigation, c) building of bean support structure with reeds.

3.1.2. Irrigation systems

Various irrigation techniques differ from one another by the way water is obtained from the source and is distributed within the field in order to obtain uniform supply of water, and to meet the requirement of each plant.

Drip irrigation: Drip irrigation is a type of micro-irrigation system that has the potential to save water and nutrients by allowing water to drip slowly to the roots of plants, either from above the soil surface or buried below the surface. The goal is to place water directly into the root zone and minimize evaporation. Emitters allow water to drip from point sources along the pipelines at a slow rate, 2-8 liters per hour, directly to the base of the plants. All droppers have very small water paths with a diameter of 0.2-2.0 mm (Figure 3.5.)

Figure 3.5. Presentation of drip irrigation-system at two different level stage of bean. a) Small vegetation of drip irrigation, b) middle vegetation of drip irrigation

Surface or furrow irrigation: Furrow irrigation is a type of surface irrigation in which trenches or “furrows” are dug between crop rows in the field. The farmers flow water down in the furrows (often by gravity) by seeping vertically and horizontally to refill the soil reservoir**.** Each flow furrow is individually controlled. This system works very well for row crops, tree crops, in effect, the water does not directly contact the plants, and conversely, such system can damage crops like potato, tomato, and vegetables by direct inundation of water. (Figure 3.6)

Figure 3.6. The view of furrow-irrigation during its application in the bean crop. a) Irrigation time in small vegetation, b) Irrigation time in middle vegetation period.

Sprinkler irrigation: DEAR DEER plastic impact sprinkler (or said as plastic impulse sprinkler), angle adjustable, with stainless steel, rotar smoothly, evenly spray, durable, long life for use. DEAR DEER plastic impact sprinkler can be used for many plants. It is a very good garden irrigation sprinkler, farm irrigation sprinkler, field irrigation in different farmland. Size: male thread 1/2", 3/4", 1", the water is conducted in tubes, under pressure, and launched into the atmosphere in the form of a jet, which fragments into drops, being distributed onto the crop and the soil of the parcel to be irrigated. It is similar to rain fall. (Figure 3.7)

Figure 3.7. The image of Sprinkler-irrigation during its application in the field. a) Sprinkler irrigation on the middle of vegetation, b) Sprinkler irrigation on the small vegetation

Weeding: Between 15- 22 days after sowing, the first control of weed was done in order to improve vegetative development and avoid the competition for nutrients between them. Also, 55-60 days after sowing, prior to the flowering period another one was done for good assimilation of nutrients and remobilization of assimilates to the pods. (Figure 3.8)

Figure 3.8. Illustration of wedding activities in the field. a) After weeding, b) weeding time, c) mechanic weeding with tractor.

3.1.3. How these data collections have to be explored in the determination the pest population and yield production on the effect of tree irrigation systems on bean.

The following observations were done in order to achieve the goals of the experiment;

- Record all insect species observed on the plants
- Observe all symptoms caused by the pests
- Evaluate the growth and development of bean plantation
- Identify all facts and details that may be influenced or affected by the treatments, providing information for the explanation and interpretation of results.

- These are some essential phenological stages to observe and assess the external behavior of the crop: the color of the foliage, the vigor of plants, the length of the different stages of growth, and reproductive organs and the observation of the sanitary state and the possible damage caused by the pests of the bean crop.

The method of collection data, the samples were the key to the results because they have significantly represented more than 10 percent of the parameters for each population studied in accordance with the objectives and technics perilously fixed. Throughout this study, data was collected on parameters previously listed according to the objectives; Data was collected on the following, some insect pest population and beneficial insects on 10 bean leaves from each parcel per treatment at different phenological stages, such as eggs, nymphal periods, and adults (Figure 3.9).

Figure 3.9. (a) Collection of dry pod bean, (b) the measure of 1000 dry grains (c) dry beans measure moisture humidity/system

Figure 3.10. Some pictures of the field and laboratory**.** (a) Reed plants as tutor, (b) grow room conditions, (c) field conditions

After collecting of leaves, they were wrapped in newspaper. Ten (10) leaves per treatment were wrapped and stored in a refrigerator at 5°C (Figure 3.11**).**

Figure 3.12.Shows preparation of leaves for observation in the laboratory.

After 3-5 days, the leaves collected inside each systems were investigated under a binocular microscope (leica S8 APO) by counting the number of the insect pests and predators at the different devlopmental stages.For example; eggs, larvae or nymphal, pre-pupae, pupae, and adult stages were recorded. (Figure 3.12).

.

Figure 3.13. Observation and counting of insect pests and predators under the bean leaf under a binocular microscope (leica S8 APO). (Figure 3.12)3.1.4. Statistical Analysis

Data collected on effects of irrigation systems, such as sprinkler, furrow, and drip irrigation on the yield parameters and some insect pest and also some insect beneficial populations were analyzed with randomized complete block design by using general linear models (GLM) with a Bonferroni correction in Spss system Software Spss (version 23). Means comparison was performed with Tukey's multiple range test ($P<0.05$) in each system in nine weeks. Also, the combined analysis for ANOVA one-way comparison in each system was used in SPSS System and Microsoft Excel.

3.2. Laboratory works

3.2.1. Rearing of the plants

For *A. fabae*, Pinto bean, *P. vulgaris* L. was cultured into the plant room. The plants were placed at a constant condition of 23±2°C and 65±10% relative humidity (RH) and a photoperiod of 16h artificial light around 10000 Lux. While for *A. craccivora*, Pinto bean leaves were collected from the field experiment in the open area. After collection, the leaves were brought to the laboratory and washed under tap running water before utilizing them. Every five days, the old leaves were substituted with new leaves for feeding quality of the insects (Figure 3.13).

3.2.2. Rearing of the insects

The black bean aphid, *A. fabae* was collected on the bean plant, Vicia fabae (Sevilla) from the experimental field of the department of plant protection, Faculty of Agriculture at Çukurova University, Balcalı/Adana/Turkey. More than 50 aphids at the adult stage were reared inside 5 cages on pinto beans (*P vulgaris* L.) in laboratory conditions at 24±1°C, 65±5% relative humidity (RH), and a photoperiod of 16:8 (L: D) 24h. Insects were used at the experiments after 5 generations (Figure.3.14). While more than 50 cowpea aphids adult, *A. craccivora* were collected from the acacia three on the Campus and the same process of reading were used for them. (Figure. 3.15).

Figure 3.14. Some pictures of the field and laboratory (a) reed plants as tutor, (b) grow room conditions, (c) field conditions, (d) aphid infested old plants, (e) fresh mature pods, (f) aphid infestation of young plants.

Figure 3.15. (a) incubator biological inside it insect cultured and 24°c (b) binocular microscope (leica S8 APO) for counting (c) room conditions of plantation (d) nymph I and, mother *Aphis fabae* (e) *Aphis fabae* adult stage (f) *Aphis fabae* young bean plant (g) mother viviparity of *Aphis fabae.*

3.2.3. Experimental procedures of *Aphis fabae and Aphis craccivora*

This study was conducted with randomly selected apterous females from the stock cage culture and individually transferred to the undersurface of fabae bean leaves in the plastic Petri dishes (both 5cm in diameter). For each level of temperature, 10 master Petri dishes as stock were placed inside of each incubator. After 3 generations, 40 Petri dishes were prepared with a wetted cotton pad (0.5 cm) and placed under the leaves such that the entire surface was covered to avoid them from drying. After that, 40 newborns were taken with a paintbrush carefully from the master stock to the new petri dishes. The cotton wool in the Petri dishes was wetted daily and every 3-5 days the aphids were transferred to new bean leaf disk. The fresh used leaves were taken from the bean growth room and brought to the citrus laboratory of Entomology at Çukurova University.

The experiments were conducted on five constant temperatures of 12, 16, 20, 24, and 28 ±1°C and 60±5% relative humidity (RH) and a photoperiod of 16:8 (L: D) 24h. For each temperature, the experiment was started with 40 newborn nymphs. Every 24 h the nymphal development was recorded until the adult stage. After the adult period, the number of newly born and survival produced by the mother were registered until the death of all adults. (Figure.3.2) and then the same methods were used for cowpea aphid, *A. craccivora*. (Figure. 3.3).

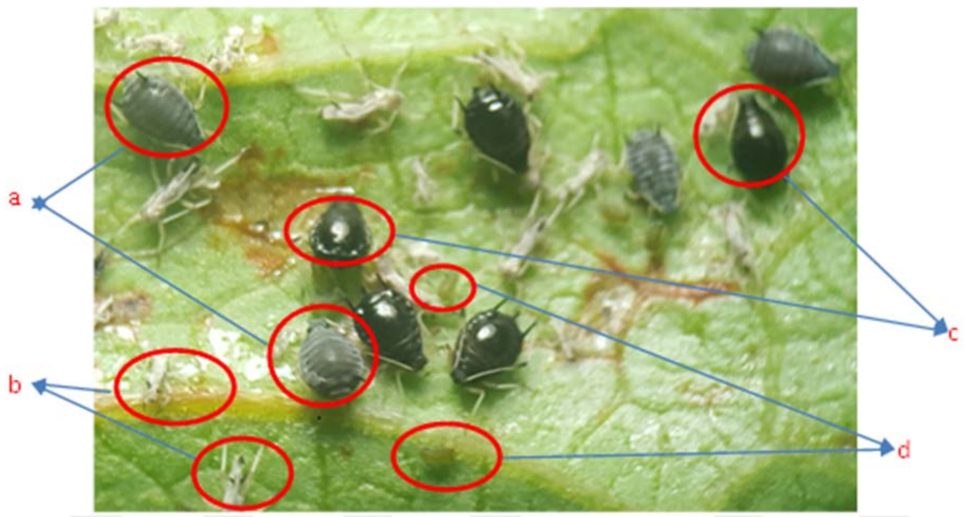


Figure 3.16. *Aphis craccivora* (a) fourth nymphal stage, (b) Aphid exoskeletons, skins or exuviae, (c) (adult stage, and (d) first nymphal stage.

3.2.4. Statistical analysis of life table and demographic parameters of *Aphis fabae* and *Aphis craccivora*.

Developmental time and reproductive performance were subjected to descriptive statistical analysis for example; the different phenological stages of *A. fabae*, including development times for nymphal molts, reproduction periods and determining lifetime of adults on each constant temperature. Furthermore, the life table parameters mentioned were calculated at five constant temperature regimes in completely randomized block design (CRBD). Eventually, the multiple comparison test of averages was done when significant difference existed using Turkey's HSD test (*P*=05). The calculations were realized using Microsoft excel, Infosat Student version, and the statistical 11.5 software SPSS (version 23) (SPSS Inc., Chicago, IL) (Green et al., 2000). For each constant temperatures curves were produced employing a product limit technique. Population growth rates were computed from the equation of Lotka (23):

$$1 = \Sigma \text{ e-r*x lx * mx} \tag{3.1}$$

In which: x = age in days, r = intrinsic rate of increase,

Lx= age-specific survival, mx = age-specific number of female offspring. After "r" was computed for the original data (rall), differences among rm-values were tested for significance differences by estimating variances through the jackknife method (24). The jackknife pseudo-value "r_j" was calculated for the "n" samples using the following equation:

$$rj = n * rall - (n-1) * ri \tag{3.2}$$

The mean of "n" jackknife pseudo-values for each treatment was subjected to analysis of variance. The scheffé test was used to compare mean growth rates for different temperature regimes (P = 0.05). Because low probability levels were used, there was no concern about inflation of experiment-wise error rates. Each of the above mentioned analyses were conducted using the Statgraphics software package.

And then, development rates of the individuals reared under the fluctuation of temperature levels were calculated by linear regression (y = a ± bx). The mean of the variation temperatures (22°C for 16, 20, 24, and28°C) was used in the regression analysis. Afterwards, the development threshold (-a/b) and thermal constant (the total effective temperature required to complete a generation, (1/b) of *A. craccivora* was calculated according to the linear regression equation (Campbell et al., 1974).

4. RESULTS AND DISCUSSIONS

4.1. Field works

4.1.1. Measurable response of yield parameters of bean *Phaseolus vulgaris* L. of three irrigation systems

The average weight (g) of green bean pods/plant with 96 plants per unit (18 m2) on the effect of three irrigation systems, such as furrow, drip, and sprinkler are presented in table 4.1 respectively, 395.99, 216.37 and 374. 24 (g). The pod number /plant was evaluated at 76.40, 51.30, and 72.05 pods. The number of unfilled pods/plant were 7. 45, 15. 50, and 12.10 respectively. The average weight of 1000grains/g were 450.66, 440.47, and 500.35 (g) respectively. The average weight of 1000 filled grains/g were 530.38, 510.21, and 570.59 (g) respectively. The last measurement was seeds number/pod which were 3. 72, 2. 23, and 3. 24 grains respectively.

Compared to some reported results by (Balkaya & Ergün, 2008), Total mean pods weight (g) per plant for each variety that were used from pinto bean (*P. vulgaris* L.) five group identifications. 1046.9, 870.7, 303.3, 491.8, 355, and 14426 respectively. And then the pod number per plant was, 65.6, 73.3, 22.9, 50.6 36.0, and 201.9 pods. Yet 100 seeds weight (g) was, 59.7, 60.2, 66.1, 55.2 70.1, and 45.45 (g) and the seed number per pod, 6.8, 5.6, 6.0, 5.7, 7.2, and 4.6 seeds were determined. Those results show clearly that the yield of drip irrigation system was decreased with the impact of insect pest populations interacting with the environment and inadaptability of drip irrigation system for in open field area on bean production.

Table 4.1. Different response of yield parameters of bean *Phaseolus vulgaris* L. during its cycle of development in open of the field under the effect of three irrigation systems. (Mean±SE)*

Irrigation-systems	**Weight/fresh pod/plant (g)**	**Nb of pod/plant**	**Nb of Unfilled pod/plant**	**Nb of filled pod/plant**	**Average weight of 1000grains/g**	**Average weight of 1000 filled grains/g**	**Nb of grains/ pod**
Furrow	395.99±25.8a	76.40±3.8a	7.4±0.95a	69.45±3.7b	450.66±10.3a	530.38±16.1b	3.72±0.1a
Drip	216.39±19.2b	51.30±4.2b	15.5±1.8b	36.30±3.5a	440.47±4.4b	510.21±9.5b	2.23±0.12c
Sprinkler	374.24±16.0a	72.05±3.5a	12.1±1.54a	60.10±3.0ab	500.35±10.5a	570.59±8.1a	3.24±0.14b

*Number of plant/unit (6*3=18 ^{m2}) 96 plants
Significant differences between means ($^{*}P < 0.05$ and $^{**}P < 0.01$) are expressed by different letters (a–c). The letters compare values in the same column.

Table 4.2. Anova table of (Mean±SE) different response of yield parameters of bean *Phaseolus vulgaris* L. during its cycle of development in opening of the field under the effect of three irrigation systems.

Measurable parameters		Sum of Squares	df	Mean Square	F	Sig.	Std
Weight/gr of green pod/systems	Between Groups	384295.330	2	192147.665	22.285	.000	121.83
Nbr of pods/plant		7196.633	2	3598.317	12.001	.000	20.28
Nbr of unfilled fruits/plant		653.233	2	326.617	7.183	.002	7.41
Nbr of filled-fruits/plant		11685.233	2	5842.617	24.638	.000	20.66
Weight/gr of 100 dry grains		386.109	2	193.054	12.150	.000	4.67
Weight/gr of 100 grains- well-filled		420.916	2	210.458	7.513	.001	5.84
Nbr of grains/pod		22.989	2	11.494	32.979	.000	0.85

According to General Linear Model results (Sig.) indicates significant effects at P = 0.05

Figure 4.1. Illustrations of yield parameters, a) five samples with four repetitions of fresh pods plant/parcel/ system, b) fresh pods unfilled and few filled c)biomass per plant and dry grains in the sun d) weight of green pods/plant e) dry grains bean f) green pod filled and unfilled g) fresh grains mature.

The mean dry grain yield (ton) per hectare is presented in the figure 4.2. The results shows on sprinkler and furrow irrigation the high values compared to drip irrigation. Reported by (Çağlar et al., 1998) obtained maximum yield from Gina variety as 15,000 kg ha^{-1} with surface irrigation in the East Mediterranean region of Turkey.

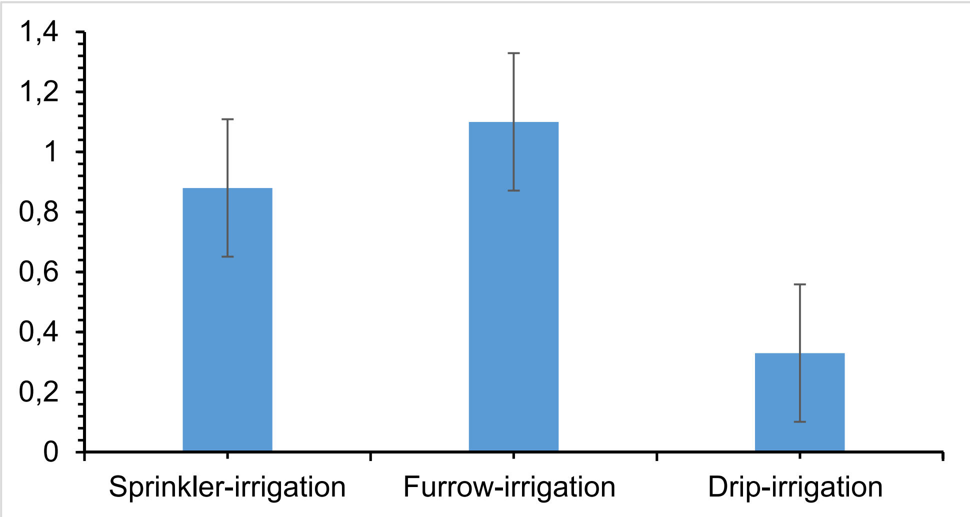


Figure 4.2. Mean dry grains yield t/ha for each irrigation systems

The yield parameters were relatively presented a similarity between sprinkler and furrow irrigation compared to drip less than 40 percent of the amount of fruits yield per hectare. Reported by (Sezen et al., 2008). Water stress gradually increased in the lower frequency irrigation treatments, and reduced green bean yield, significantly. Higher frequency irrigation with high Kcp values created favorable soil water environment for green bean growth and resulted in higher yields. Figure 4.3.

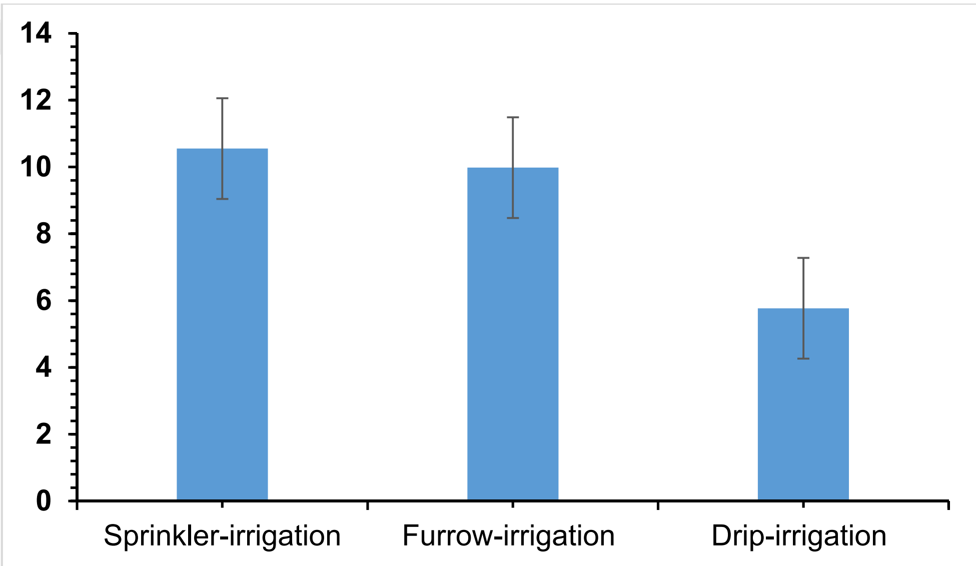


Figure 4.3. Mean fresh pods yield t/ha for each irrigation systems

From the irrigation, the highest humidity value was recorded from furrow irrigation compared to drip and sprinkler irrigation. Concerned the capacity of holding water in the soil allowed the plants to stay a more longtime with the green leaves compared to sprinklers in furrow irrigation. This was caused by the power of retention water in soil profile. As reported by (Graterol et al., 1993), there was no effect of furrow irrigation spacing on soil water change in the 1.52 m soil profile during the irrigation season. Alternate-furrow irrigation produced the same yield as every-furrow irrigation with less water input leading to water conservation Figure 4.4.

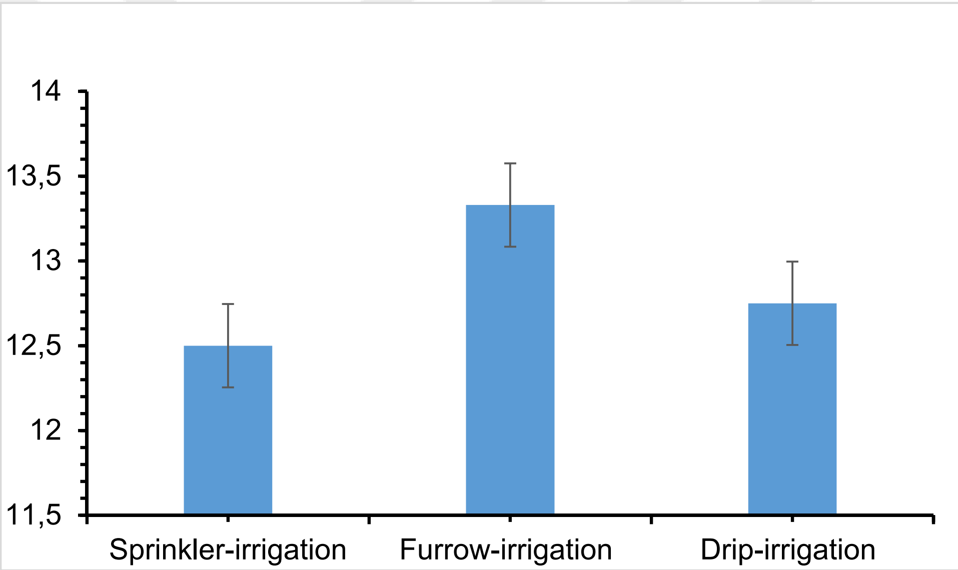


Figure 4.4. Representative of the humidity (%) of dry grains for each irrigation system

The mean value biomass/plant (kg) per irrigation system was presented in (figure 4.5). The mean values of biomass per plant for each system show that furrow and sprinkler irrigation were a bit similar in terms of weight compared to drip irrigation that decreased Therefore, drip irrigation in its side decreases less than 25% compared to both. This was caused by the effect of factor abiotic and biotic. According to (Wakrim et al., 2005), both regulated deficit irrigation and partial root zone-drying treatments resulted in significant reduction of common bean shoot and pod biomass, compared with well-watered treatments. Noted that this study was conducted without using fertilizers. For that reason, all the studied parameters for each system on bean development cycle were significantly decreased compared to the previous works.

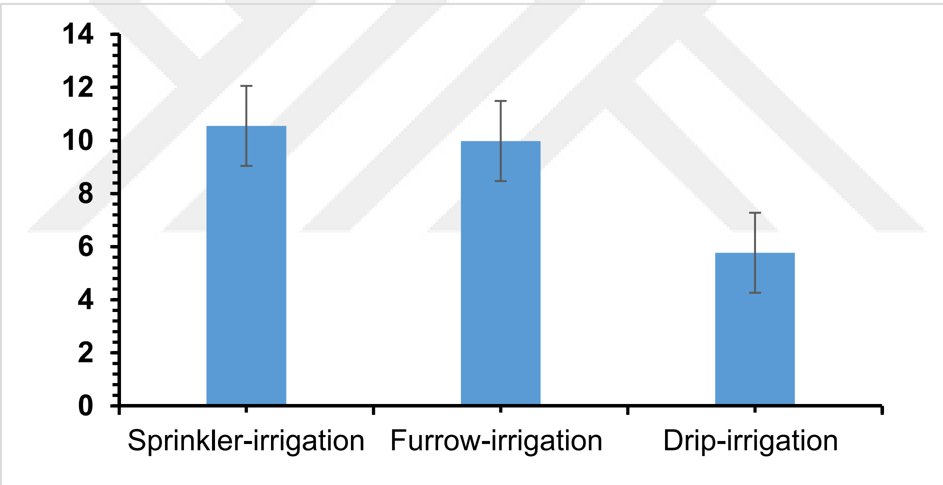


Figure 4.5. Representation of biomass (kg) of plant for each irrigation system.

4.1.2. Effect of irrigation systems on some insect population on bean growth and development stages in Adana region.

4.1.2.1. Effect of *Aphis fabae* nymph and adult on the production of pinto bean (*Phaseolus vulgaris* L.).

The fluctuation of the *A. fabae* population varies with the effects of different climatic factors, such as precipitation, humidity, wind, and temperature during nine weeks. The different irrigation systems affected the biological development of these pests differently. For this reason, the population dynamics of *A. fabae* nymphs and adult show in (figure 4.5 and 4.6) respectively. From drip irrigation, two important peak levels at the nymph and adult stages were recorded on 14th May and 18th June 2020. According to consecutive observations, drip irrigation allows a favorable condition for *A. fabae* development. For the nymph stages, the population was standardized for sprinkler and furrow irrigation due to high humidity. For the sprinkler and furrow irrigation, the rapid development and lignification of the new leaf and bund plants with abundant trichome on them could serve as a barrier for a suck-feeding part mouth like aphid species. In addition, the inadequate circulation of wind within both systems due to high foliage density and concentration of water in the soil increased the area's humidity which affected the growth and development aphid stages. As can be remarked in the furrow-irrigation on 18th June 2020 there was a slight increase in aphid population which was provoked by the presence of rainfall in this period. The results clearly reveal that drip irrigation is one of the most suitable systems for *A. fabae* pests evolution via rapid evapotranspiration potential of water from the small density of Canopy and radiation to the soil were engendered stress and low growth to the plants. (Ekram et al., 2019) recorded the main pests during two successive spring seasons of 2017 and 2018. The total number of *A. craccivora* were 1125.63 individuals/25 leaves, and *A. gossypii* were 94.33 individuals/25 leaves; while summer seasons mid of February a total number of *A .gossypii* were 80.67 individuals/25 and leaves. According to (Abd El-Gawward, 2008) during two successive summer seasons

2014 and 2015 the total number cowpea aphid, *A. craccivora* were 694.25 and, 523.26 individuals/25 leaves.

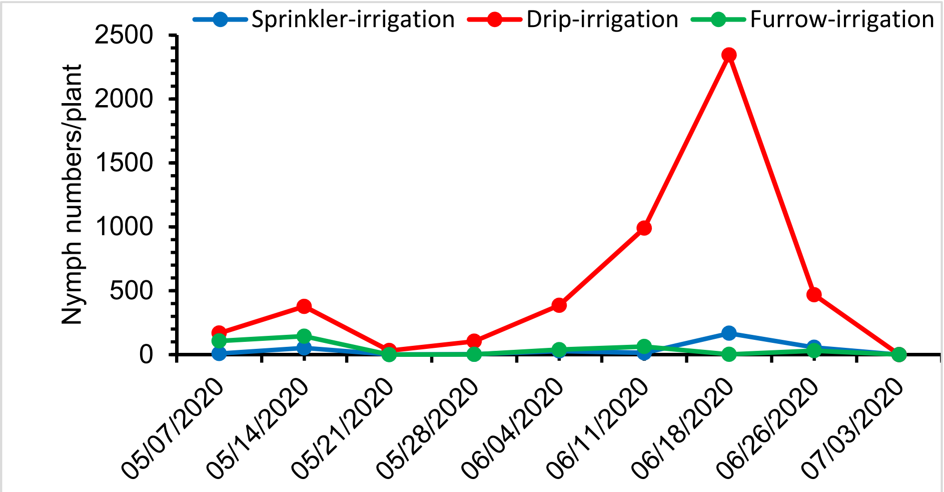


Figure 4.6. Explains the average estimation of *Aphis fabae* nymphs on the effect of three irrigation systems on the bean culture during nine weeks in the field

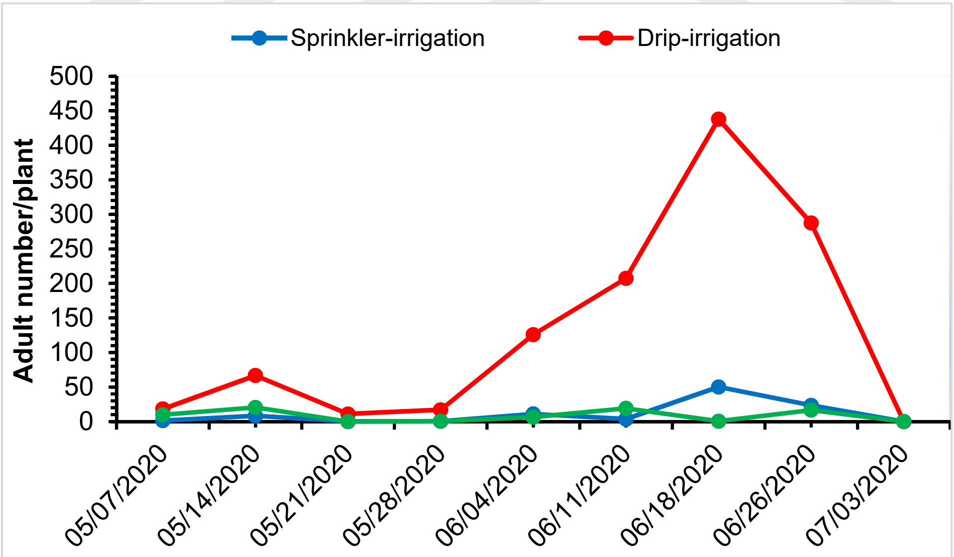


Figure 4.7. Explains the average estimation of *Aphis fabae* adult stage on the effect of three irrigation systems on the bean plant during 9 weeks in the field

Table 4.3. Representative of the total *Aphis fabae* adult stage interactions between the different factors studied on bean.

Source	Type III Sum of Squares	df	Mean Square *A. fabae* adult	F	Sig.
Corrected Model	11042818.896	26	424723.804	10.172	.000
Intercept	2675953.779	1	2675953.779	64.087	.000
Irrigation-systems	3493355.341	2	1746677.670	41.832	.000
Weeks	3056251.030	8	382031.379	9.149	.000
Irrigation-systems * Weeks	4493212.526	16	280825.783	6.726	.000
Error	43967934.325	1053	41754.923		
Total	57686707.000	1080			
Corrected Total	55010753.221	1079			

R Squared = 0.201 (Adjusted R Squared = 0.181)
According to General Linear Model results **(Sig.)** indicates significant effects at P = 0.05

Table 4.4. Representative of the total *Aphis fabae* nymph stages interactions between the different factors studied on bean.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	237625293.500	26	9139434.365	16.921	.000
Intercept	46191261.675	1	46191261.675	85.521	.000
Irrigation systems	60298604.539	2	30149302.269	55.820	.000
Weeks	65588404.150	8	8198550.519	15.179	.000
Irrigation systems * Weeks	111738284.811	16	6983642.801	12.930	.000
Error	568741345.825	1053	540115.238		
Total	852557901.000	1080			
Corrected Total	806366639.325	1079			

R Squared = .295 (Adjusted R Squared = .277)
According to General Linear Model results **(Sig.)** indicates significant effects at P = 0.05

Table 4.5. Total average values of *Aphis fabae* nymphs and adult stages under the effect of irrigation systems during nine weeks on bean plant in the open field.

Irrigation-systems	*A fabae*	N	Mean±SE
Sprinkler-irrigation	Nymph stages	360	36.56 ± 9.6b
Furrow-irrigation		360	42.91±8.2b
Drip-irrigation		360	540.95±74.9a
Sprinkler-irrigation	Adult stage	360	10.91±2.7b
Furrow-irrigation		360	8.16±1.8b
Drip-irrigation		360	130.19±19.6a

Significant differences between means ($^{*}P < 0.05$ and $^{**}P < 0.01$) are expressed by different letters (a–b). The letters compare values in the same column.

Table 4.6. Anova of *Aphis fabae* nymph stages and adult under the effect of irrigation systems, between sprinkler-irrigation, drip-irrigation, and furrow-irrigation during nine weeks on bean plant in the open field.

Aphis fabae	Groups	Sum of Squares	df	Mean Square	F	Sig.
Nymph	Between Groups	60298604.539	2	30149302.269	43.523	.000
Adult	Between Groups	3494908.156	2	1747454.078	36.531	.000

4.1.2.2. White fly, *Bemisia Tabaci* egg, larvae, and adult stages number on the cycle of pinto bean production (*Phaseolus vulgaris* L.).

The number of *B. tabaci* egg, larvae, and adult stages were counted under a binocular microscope (Leica S8 APO) on bean leaves from different irrigation systems during 9 weeks. The results show a significant difference from furrow through egg and adult stages compared to the others. These differences were provoked by high humidity which caused saturation of the soil by flowing-water (Table.4.5). The results from 26th June to 3 rd. July 20 (Figure 4.6 and 4.5) show the peaks in the summer growing season. Reported by (Safe et al., 2018) in the study that was conducted on the relationship between temperature and relative humidity (RH) on *B. tabaci* population density infesting on bean production. The weekly average densities of *B. tabaci* were monitored over the summer of 2013 and 2014 on common bean cultivars. There was a significant difference ($F = 9.37$, $df = 66$, $P = 0.031$) in the average population density of whitefly larvae among all cultivars during the summer cropping seasons. And also reported by (Ekram et al., 2019) that the recorded of the main pests during two successive summer seasons mid of February plantation (2017 and 2018) *B. tabaci* (immature stages) represented by 222.33 individuals/25 leaves, (Gamila et al, 2016). Generally, the data indicate that the whitefly density reached a peak when the relative humidity was less than 65%.

The data illustrated in the figure. 6,7, and 8 showed that the weekly population fluctuations of *B. tabaci* infesting broad bean plants on the effect of three irrigation systems during nine successive weeks. The initial incidence of this pest occurred relatively three peaks for the adult stage on the effect furrow irrigation was recorded at 5th May, 6th, and 26th June 2020 during this seasons. *B. tabaci* was presented a peak during 18th June in furrow and 3 July 2020 on sprinkler irrigation growing seasons on broad bean plants. Finally, the number of laying eggs was presented a peak on the first week of June 2020. Reported by (Selem et al., 2016) , the cotton whitefly, *B. tabaci* (immature stages) two peaks were recorded for the population density, the first one occurred on 5th May with the mean number of 15 and 12.66 insects/25 leaf at the mean of 21.0ºC, 22.1ºC with 56.7% and 65.4% relative Humidity (RH). The second peak occurred in the first week of June with the mean number of 21.33 and 17 insects/25leaf at the mean of 24.9ºC, 25.7ºC with 57.0% and 57.1% relative humidity (RH) for the two seasons. These results agree with the findings of (EI-Sayed e t al., 1991) who showed that high rate of infestation with *B. tabaci* immature stages on bean leaf in all plantations (early summer, summer and winter). Also El-Khayat et al. (1994)

estimated the relative population density of *B. tabaci* stages on leaves of summer vegetable crops at two locations in Qalubiya Governorate Moshtohor and, El-Kanater ElKhaireia.

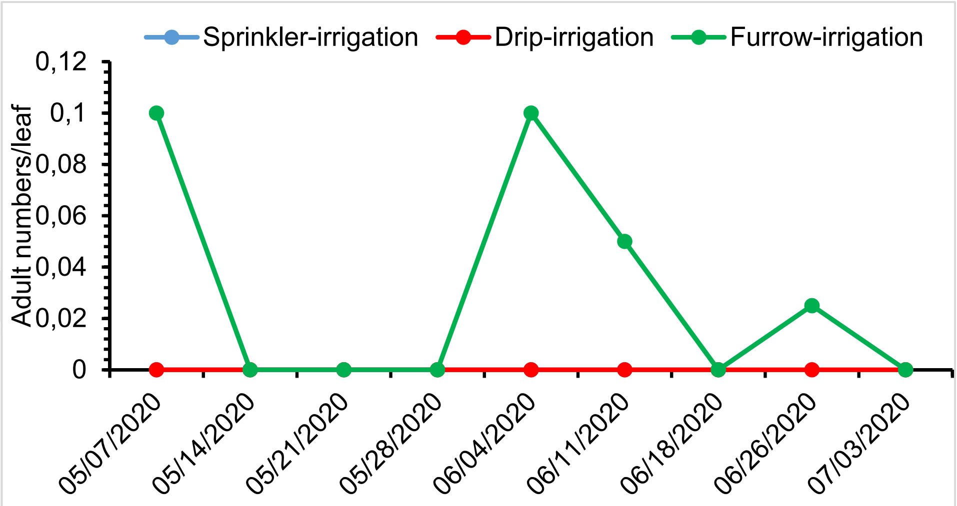


Figure 4.8. Explains the average is estimation of white fly *Bemisia tabaci* adult on the effect of three irrigation systems on the bean culture during 9 weeks in the field

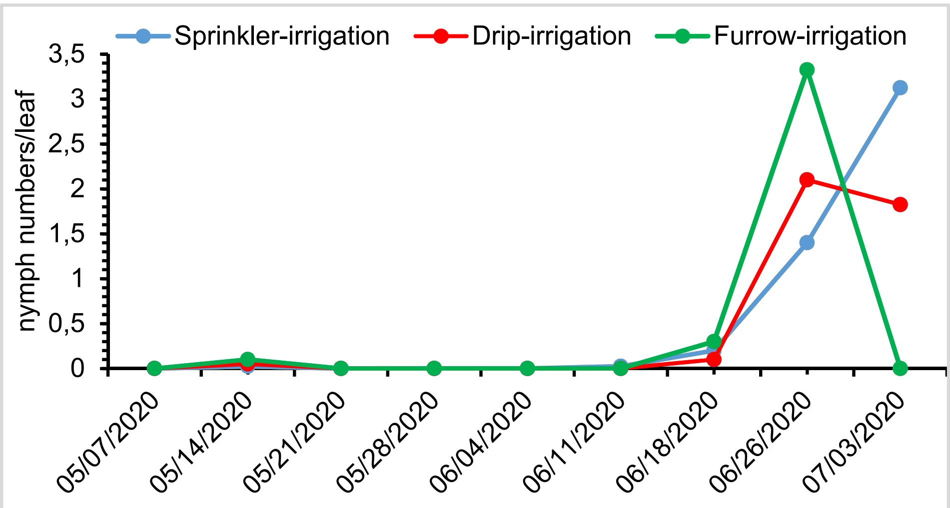


Figure 4.9. Explains the average estimation of white fly *Bemisia tabaci* nymph stages on the effect of three irrigation systems on the bean culture during 9 weeks in the field.

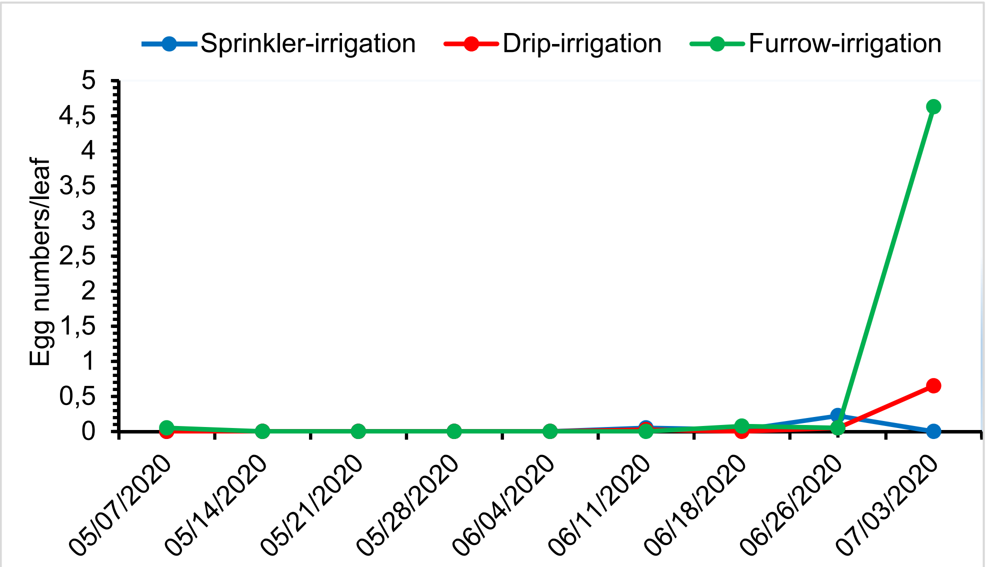


Figure 4.10. Explains the average estimation of with fly *Bemisia tabaci eggs* on the effect of three irrigation systems on the bean culture during 9 weeks in the field.

Table 4.7. Representative of the total interactions of *Bemisia tabaci* eggs between the different factors and weeks on the bean.

Source	Type III Sum of Squares	df	Mean Square of *B. tabaci* eggs	F	Sig.
Corrected Model	824.957	26	31.729	24.535	.000
Intercept	50.268	1	50.268	38.870	.000
Irrigation-systems	54.869	2	27.434	21.214	.000
Weeks	322.391	8	40.299	31.161	.000
Irrigation-systems * Weeks	447.698	16	27.981	21.637	.000
Error	1361.775	1053	1.293		
Total	2237.000	1080			
Corrected Total	2186.732	1079			

R Squared = .377 (Adjusted R Squared = .362)
According to General Linear Model results **(Sig.)** indicates significant effects at P = 0.05

Table 4.8. Representative of the total interactions of *Bemisia tabaci* nymph stages between the different factors and weeks on the bean

Source	Type III Sum of Squares	df	Mean Square of *B. tabaci* nymphs	F	Sig.
Corrected Model	992.757	26	38.183	20.410	.000
Intercept	234.268	1	234.268	125.222	.000
Irrigation-systems	2.541	2	1.270	.679	.507
Weeks	718.724	8	89.841	48.022	.000
Irrigation-systems * Weeks	271.493	16	16.968	9.070	.000
Error	1969.975	1053	1.871		
Total	3197.000	1080			
Corrected Total	2962.732	1079			

R Squared = .335 (Adjusted R Squared = .319)
According to General Linear Model results **(Sig.)** indicates significant effects at P = 0.05

Table 4.9. Representative of the total interactions of *Bemisia tabaci* adult between the different factors and weeks on the bean

Source	Type III Sum of Squares	df	Mean Square of *B. tabaci* adult	F	Sig.
Corrected Model	.817	26	.031	1.940	.003
Intercept	.133	1	.133	8.235	.004
Irrigation systems	.206	2	.103	6.348	.002
Weeks	.200	8	.025	1.544	.138
Irrigation systems * Weeks	.411	16	.026	1.587	.065
Error	17.050	1053	.016		
Total	18.000	1080			
Corrected Total	17.867	1079			

R Squared = .046(Adjusted R Squared = .022
According to General Linear Model results **(Sig.)** indicates significant effects at P = 0.05

Table 4.10. Average values of *Bemisia tabaci* eggs, larvae, and adult under the effect of irrigation systems, such as sprinkler-irrigation, drip-irrigation, and furrow-irrigation during 9 weeks on bean leaves

Irrigation-systems	Bemisia tabaci)	Number of bean leaves	Mean±SEM
Sprinkler-irrigation	Eggs	360	0.33 ± 0.1b
Drip-irrigation		360	0.08 ± 0.6b
Furrow-irrigation		360	0.53 ± 0.1a
Sprinkler-irrigation	Larvae	360	0.53 ± 0.1
Drip-irrigation		360	0.45 ± 0.1
Furrow- irrigation		360	0.41 ± 0.1
Sprinkler-irrigation	Adults	360	0.00 ± 0.0b
Drip-irrigation		360	0.002 ± 0.01b
Furrow-irrigation		360	0.03± 0.0a

Significant differences between means ($^{*}P < 0.05$ and $^{**}P < 0.01$) are expressed by different letters (a–b). The letters compare values in the same column.

Table 4.11. Anova of *Bemisia tabaci* eggs, larvae, and adult stages on the effect of irrigation systems, between sprinkler-irrigation, drip-irrigation, and furrow-irrigation during 9 weeks on bean leaves

Bemisia tabaci		Sum of Squares	df	Mean Square	F	Sig.
Eggs	Between Groups (Combined)	36.575	2	18.288	9.160	0.000
Larva		2.312	2	1.156	0.421	0.657
Adults		0.205	2	0.103	6.258	0.002

4.1.3. *Empoasca decipiens* nymph and adult population stages on bean under the effect of three irrigation-systems

E. decipiens larvae and adult on the effect of three irrigation systems were counted during nine weeks under the surface of bean leaves for each system. The founded results were shown some significant differences between the weeks, respectively, the population was started increasing on 18th June, 26th June, and 3rd

July 2020. Particularly, the most increasing peak was on 26th June 2020 (during summer) on sprinkler-irrigation. Reported by Ekram et al., 2019, the total number of the main pests were recorded on P. vulgaris plants during summer seasons in 2017 and 2018. Mahmoud et al., 2011 studied the population fluctuation of the leafhopper E. decipiens on some plantations such as broad bean, green bean, pea, during the winter season of 2008-2009 at El-Kanater El-Khairia farm, Kalubia Governorate. The data showed that *E. decipiens* had presented two peaks during its winter activity. In this study, the impact of this pest was significantly and positively correlated with maximum temperature and maximum relative humidity Hanafy et al., 2014. As we can see the peak elevation on furrow and sprinkler irrigation, this increase explains the presence of high humidity inside them.

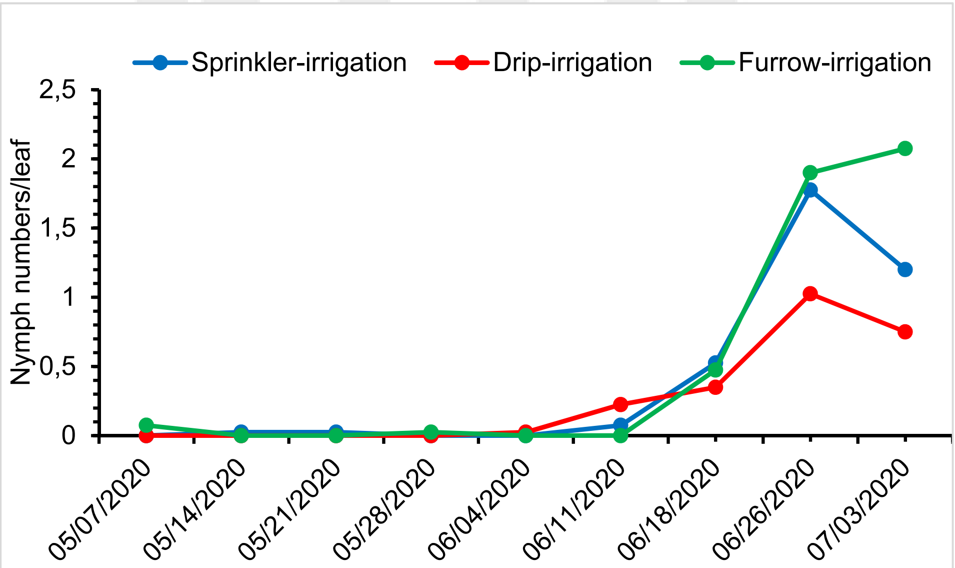


Figure 4.11. Explains the average estimation of *Empoasca decipiens* nymphs on the effect of three irrigation systems on the bean culture during 9 weeks in the field

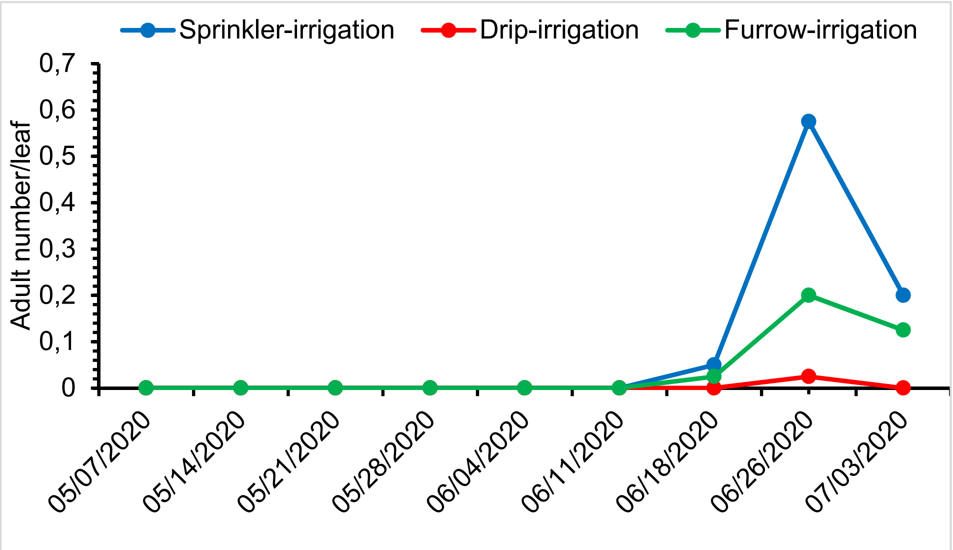


Figure 4.12. Explains the average estimation of *Empoasca decipiens* adult on the effect of three irrigation systems on the bean culture during nine weeks in the field

Table 4.12. Representative of the total interactions of *Empoasca decipiens* nymphs between the different factors and weeks on the bean.

Source	Type III Sum of Squares	df	Mean Square of *E. decipiens* nymphs	F	Sig.
Corrected Model	427.407	26	16.439	26.643	.000
Intercept	164.893	1	164.893	267.249	.000
Irrigation systems	10.591	2	5.295	8.582	.000
Weeks	371.257	8	46.407	75.214	.000
Irrigation systems * Weeks	45.559	16	2.847	4.615	.000
Error	649.700	1053	.617		
Total	1242.000	1080			
Corrected Total	1077.107	1079			

R^2= .397 (Adjusted R Squared = .382)
According to General Linear Model results **(Sig.)** indicates significant effects at P = 0.05

Table 4.13. Representative of the total interactions of *Empoasca decipiens* adult between the different factors and weeks on the bean.

Source	Type III Sum of Squares	df	Mean Square of *E. decipiens*	F	Sig.
Corrected Model	15.067	26	.579	8.382	.000
Intercept	2.133	1	2.133	30.857	.000
Irrigation systems	1.439	2	.719	10.406	.000
Weeks	7.883	8	.985	14.253	.000
Irrigation systems * Weeks	5.744	16	.359	5.193	.000
Error	72.800	1053	.069		
Total	90.000	1080			
Corrected Total	87.867	1079			

R^2 = .171 (Adjusted R Squared = .151)
According to General Linear Model results **(Sig.)** indicates significant effects at P = 0.05

Table 4.14. Average values of *Empoasca decipiens* nymph and adult stages under the effect of irrigation systems, such as sprinkler-irrigation, drip-irrigation, and furrow-irrigation during 9 weeks on bean leaves.

Irrigation- systems	*Empoasca decipiens*	N	Mean±SEM
Sprinkler-irrigation	Nymphs	360	0.402 ± 0.05 a
Drip-irrigation		360	0.263 ± 0.03 b
Furrow-irrigation		360	0.505 ± 0.06 a
Sprinkler-irrigation	Adult	360	0.091± 0.02 a
Drip-irrigation		360	0.002 ± 0.01b
Furrow-irrigation		360	0.038 ± 0.01b

Significant differences between means ($^{*}P < 0.05$ and $^{**}P < 0.01$) are expressed by different letters (a–b). The letters compare values in the same column.

Table 4.15. Anova of *Empoasca decipiens* nymph and adult stages on the effect of irrigation systems, between sprinkler-irrigation, drip-irrigation, and furrow-irrigation during 9 weeks on bean leaves.

Empoasca decipiens	Between Groups(Combined)	Sum of Squares	df	Mean Square	F	Sig.
Nymphs		14.246	2	7.123	7.218	.001
Adult		1.846	2	0.923	8.694	.000

4.1.4. *Frankliniella occidentalis* and *Thrips tabaci* larvae, and adult stages number on the cycle of production of pinto under the effect of three irrigation-systems

F. occidentalis and *T. tabaci* larvae, and adult stages under the effects of three irrigation on bean plants were resulted that drip irrigation and furrow the effects were more significant than drip as you can see in the figure 4.14 and 4.15, the peaks were presented in the summer time on at the second week of June until the end. Those have been explained through the abundant availability of water released both systems associated with increasing of the temperature were occurred a humidity relative at its development while at the side of drip, the population was less dense. Despite of that, the damages have been more considerable than the others because hydric stress reduce the capacity of the plant to resist or defense against the pests.

It is evident that irrigation plays a major role in the growth and Development of any culture, and also for the pest or beneficial insects whereas an excess or less quantity of water can be annoyed both of them. That is why, a reasonable quantity advantageous must be applied for best yield and a good management of water. Reported the *F. occidentalis* and *T. tabaci* were active on weeds and reproduced to a small extent in temperate days of the winter months in the eastern Mediterranean of Turkey. While the differences in the abundance of Thrips may correspond to abundance and numbers of weed species sampled in each site (Atakan & Uygur, 2005).

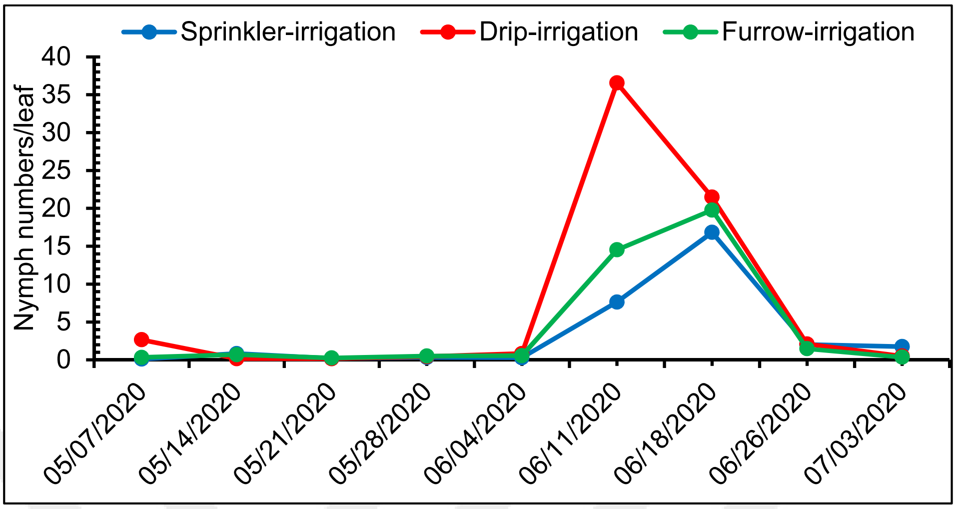


Figure 4.13. Explains the average estimation of *Frankliniella occidentalis* and *Thrips tabaci* nymphs on the effect of three irrigation systems on the bean culture during 9 weeks in the field

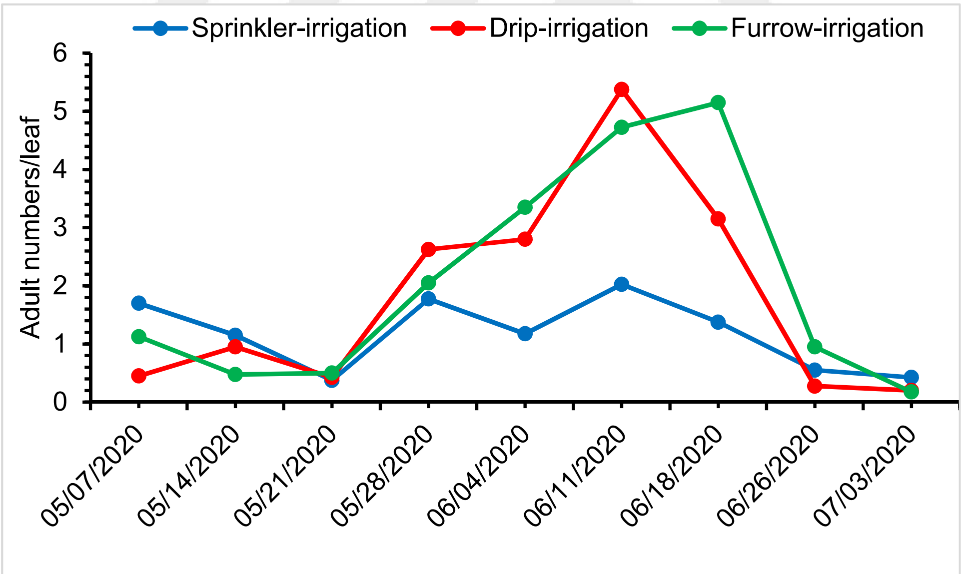


Figure 4.14. Explains the average estimation of *Frankliniella occidentalis and Thrips tabaci* adult on the effect of three irrigation systems on the bean culture during 9 weeks in the field.

Table 4.16. Representative of the total interactions of *Frankliniella occidentalis and Thrips tabaci* adult stage between the different factors and weeks on the bean

Source	Type III Sum of Squares	df	Mean Square of *Thrips Sp* adult stage	F	Sig.
Corrected Model	2449.917	26	94.228	27.244	.000
Intercept	3040.133	1	3040.133	878.996	.000
Weeks	149.267	2	74.633	21.579	.000
Irrigation- systems	1742.750	8	217.844	62.985	.000
Weeks * Irrigation- systems	557.900	16	34.869	10.082	.000
Error	3641.950	1053	3.459		
Total	9132.000	1080			
Corrected Total	6091.867	1079			

R^2= .402 (Adjusted R Squared = .387)
According to General Linear Model results **(Sig.)** indicates significant effects at P = 0.05

Table 4.17. Representative of the total interactions of *Frankliniella occidentalis and Thrips tabaci* nymphs between the different factors and weeks on the bean

Source	Type III Sum of Squares	df	Mean Square of *Thrips. Sp* nymphs	F	Sig.
Corrected Model	84303.241	26	3242.432	45.494	.000
Intercept	26274.934	1	26274.934	368.660	.000
Irrigation-systems	2944.030	2	1472.015	20.654	.000
Weeks	65369.191	8	8171.149	114.648	.000
Irrigation-systems * Weeks	15990.020	16	999.376	14.022	.000
Error	75048.825	1053	71.271		
Total	185627.000	1080			
Corrected Total	159352.066	1079			

R Squared = .529 (Adjusted R Squared = .517)
According to General Linear Model results **(Sig.)** indicates significant effects at P = 0.05

Table 4.18. Average values of *Frankliniella occidentalis and Thrips tabaci* larvae (nymphs) and adult on the effect of irrigation systems, such as sprinkler-irrigation, drip- irrigation, and furrow-irrigation during 9 weeks on bean leaves

Irrigation systems	Thrips	N	Mean±SEM
Sprinkler-irrigation	nymphs	360	3.32±0.4b
Drip-irrigation		360	7.20±0.9a
Furrow-Irrigation		360	4.26±0.5b
Sprinkler-irrigation	Adult	360	1.17±0.7b
Drip-irrigation		360	1.80±0.1a
Furrow-Irrigation		360	2.05±0.1a

Significant differences between means ($^{*}P < 0.05$ and $^{**}P < 0.01$) are expressed by different letters (a–b). The letters compare values in the same column.

Table 4.19. Anova of *Frankliniella occidentalis and Thrips tabaci* larvae (nymphs) and adult stages under the effect of irrigation systems, between sprinkler-irrigation, drip-irrigation, and furrow-irrigation during 9 weeks on bean leaves

Thrips		Sum of Squares	df	Mean Square	F	Sig.
Nymphs	Between Groups(Combined)	2944.030	2	1472.01	10.13	.000
Adult		149.267	2	74.63	13.52	.000

4.1.5. *Tetranychus urticae*, egg, nymph, and adult stages number on the cycle of production of pinto bean under the effect of three irrigation systems.

T. urticae under the effect of three irrigation-systems resulted in the number of eggs, nymphs, and adult stages were significant differences among all of them, especially from drip-irrigation (Table.4.20). From the weekly counting, we have recorded two peaks on 26th June for egg and adult stages and one for nymph on 18th (2020). (Figure 4.13). Our finding revealed that the population characteristics of *T. urticae* under the effect of drip on bean are higher than the others, this indicated that the fluctuation of the temperature plays a preponderant role in the population's dynamics parameters of this mite through its influence on survival and reproduction. Reported by (Ahmadi, 1983), these results provide that *T. urticae* has a high fecundity rate on cotton compare to some other hosts and another mites or insects. Bounfour and Tanigoshi, 2001 also reported that population increase for *T. urticae* is more favored by high temperatures.

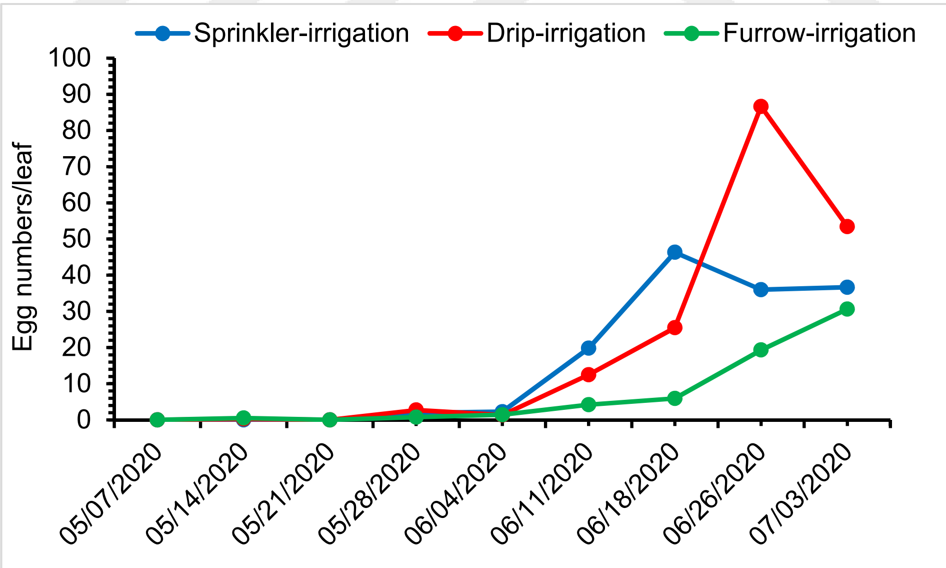


Figure 4.15. Explains the average estimation of *Tetranychus urticae egg* numbers on the effect of three irrigation systems on the bean culture during 9 weeks in the field

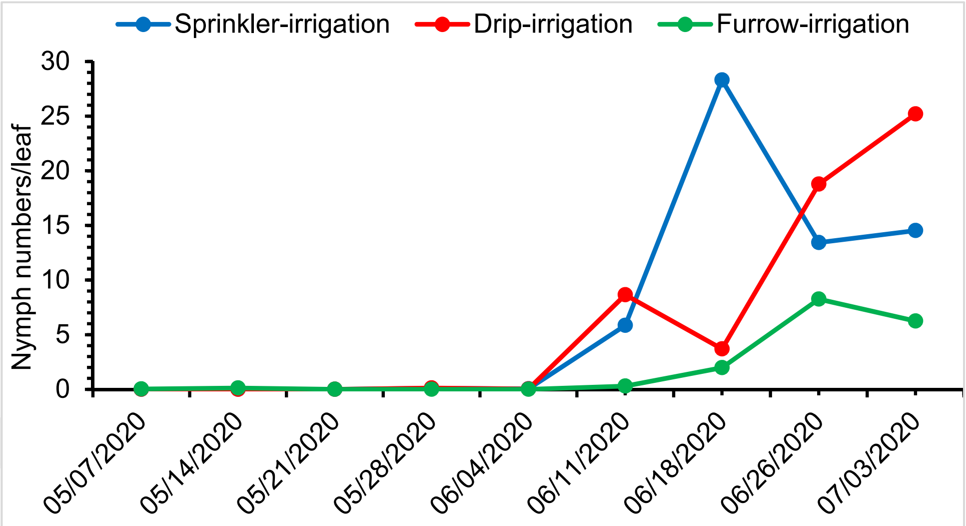


Figure 4.16. Explains the average estimation of *Tetranychus urticae* nymphs on the effect of three irrigation systems on the bean culture during 9 weeks in the field

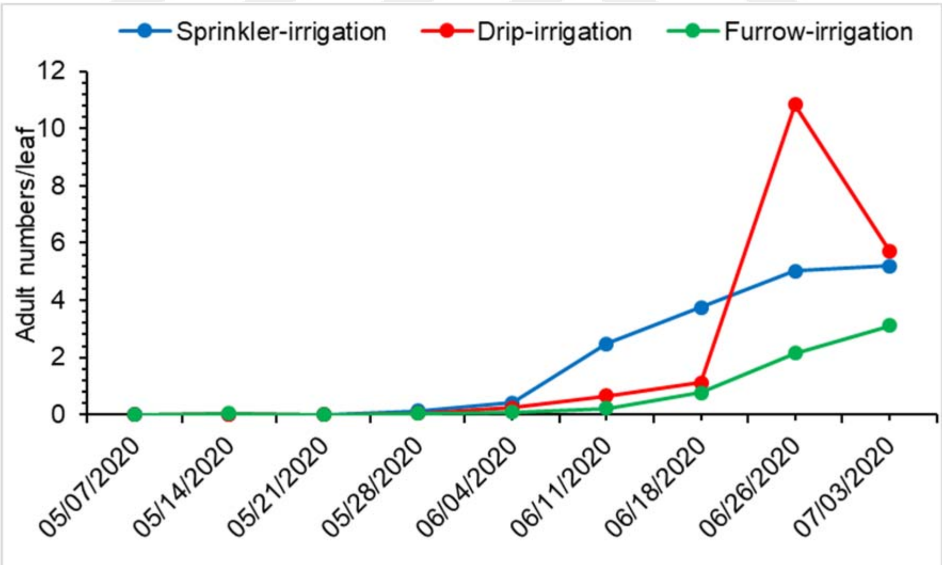


Figure 4.17. Explains the average estimation of *Tetranychus urticae* adult on the effect of three irrigation systems on the bean culture during 9 weeks in the field

Table 4.20. Representative of the total interactions of *Tetranychus urticae* eggs between the different factors and weeks on the bean

Source	Type III Sum of Squares	df	Mean Square of *T. urticae* eggs	F	Sig.
Corrected Model	485731.95	26	18681.99	21.40	.000
Intercept	223028.14	1	223028.14	255.49	.000
Irrigation systems	32987.80	2	16493.90	18.89	.000
Weeks	338718.06	8	42339.75	48.50	.000
Irrigation systems * Weeks	114026.08	16	7126.63	8.16	.000
Error	919201.90	1053	872.93		
Total	1627962.00	1080			
Corrected Total	1404933.85	1079			

According to General Linear Model results **(Sig.)** indicates significant effects at P = 0.05
R^2= .346 (Adjusted R Squared = .330)

Table 4.21. Representative of the total interactions of *Tetranychus urticae* nymphs between the different factors and weeks on the bean

Source	Type III Sum of Squares	df	Mean Square of *T. urticae* nymphs	F	Sig.
Corrected Model	69280.67	26	2664.64	16.40	.000
Intercept	27260.62	1	27260.62	167.83	.000
Irrigation systems	5410.23	2	2705.11	16.65	.000
Weeks	41050.25	8	5131.28	31.59	.000
Irrigation systems * Weeks	22820.18	16	1426.26	8.78	.000
Error	171036.70	1053	162.42		
Total	267578.00	1080			
Corrected Total	240317.374	1079			

According to General Linear Model results **(Sig.)** indicates significant effects at P = 0.05
R^2 = .288 (Adjusted R Squared = .271)

Table 4.22. Representative of the total interactions of *Tetranychus urticae* adult between the different factors and weeks on the bean.

Source	Type III Sum of Squares	df	Mean Square of *T. urticae* adult	F	Sig.
Corrected Model	6940.357	26	266.937	23.327	.000
Intercept	2625.793	1	2625.793	229.460	.000
Irrigation systems	386.724	2	193.362	16.897	.000
Weeks	4900.907	8	612.613	53.534	.000
Irrigation systems * Weeks	1652.726	16	103.295	9.027	.000
Error	12049.850	1053	11.443		
Total	21616.000	1080			
Corrected Total	18990.207	1079			

According to General Linear Model results **(Sig.)** indicates significant effects at P = 0.05
R 2= .365 (Adjusted R Squared = .350

Table 4.23. Average values of *Tetranychus urticae* egg, nymph, and adult stages under the effect of irrigation systems, such as sprinkler-irrigation, drip-irrigation, and furrow-irrigation during 9 weeks on bean leaves

Tetranychus Urticae		Sum of Squares	df	Mean Square	F	Sig.
Eggs	Between Groups(Combined)	32987.80	2	16493.90	12.94	.000
Nymphs		5410.23	2	2705.11	12.40	.000
Adult		386.72	2	193.36	11.19	.000

Table 4.24. Anova of *Tetranychus urticae* egg, nymph, and adult stages under the effect of irrigation systems between sprinkler-irrigation, drip-irrigation, and furrow-irrigation during 9 weeks on bean leaves

Irrigation systems	*T. urticae*	N	Mean±SEM
Sprinkler-irrigation	Eggs	360	15.88 ± 1.5 a
Drip-irrigation		360	29.25 ± 2.7a
Furrow-Irrigation		360	6.97 ± 0.9b
Sprinkler-irrigation	Nymphs	360	6.91 ± 0.8a
Drip-irrigation		360	6.36 ± 0.9a
Furrow-Irrigation		360	1.88 ± 0.3 b
Sprinkler-irrigation	Adult	360	1.88 ± 0.2a
Drip-irrigation		360	2.06 ± 0.3a
Furrow-Irrigation		360	0.71 ± 0.1b

Significant differences between means (*P < 0.05 and **P < 0.01) are expressed by different letters (a–b). The letters compare values in the same column

4.1.6. Leaf miner *Liriomyza trifolii* larvae, pupa, and adults stages number on the cycle of production of pinto bean under the effect of three irrigation systems

In summer times, especially on June referring at the figure 4.16, 17, and 18 the interaction between the high degree of temperature with the use of furrow irrigation and sprinkler-irrigation have provoked an high evaporation from the soil this engendered an augmentation of humidity rate in both systems in which effected the physiologic development of this insects *L. trifolii* Revealed study of the life history of the American serpentine leaf miner *L. trifolii* has been carried out both in the field and in the laboratory. The life cycle was found to be dependent on temperature and relative humidity. Related by (Owino, 2014). The results show that temperature has significant effect on development time of egg, larvae and pupal of *L. trifolii*. Development time showed an inverse relationship with temperature.

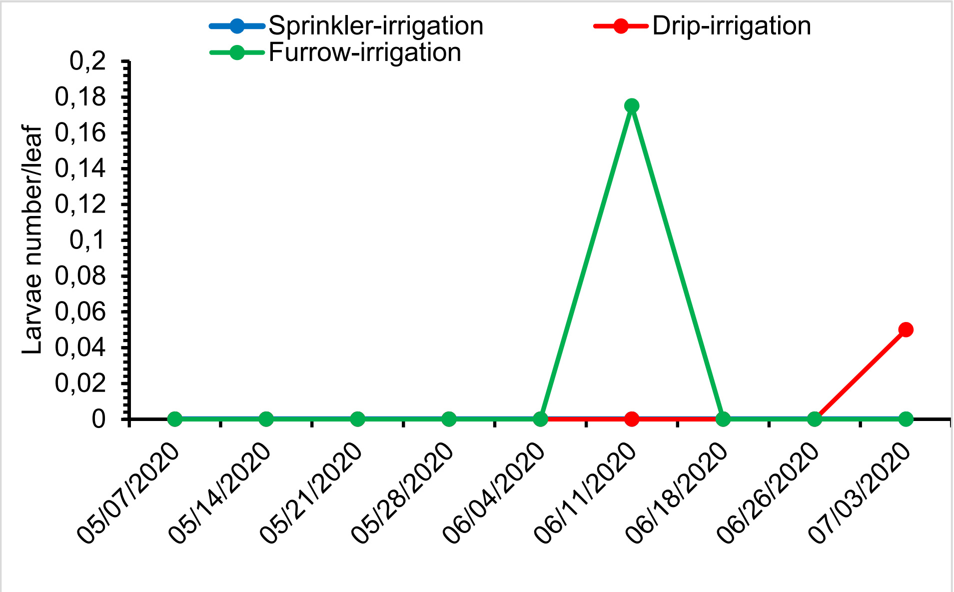


Figure 4.18. Explains the average estimation of Leaf miner, *Liriomyza trifolii* larvae on the effect of three irrigation systems on the bean culture during 9 weeks in the field.

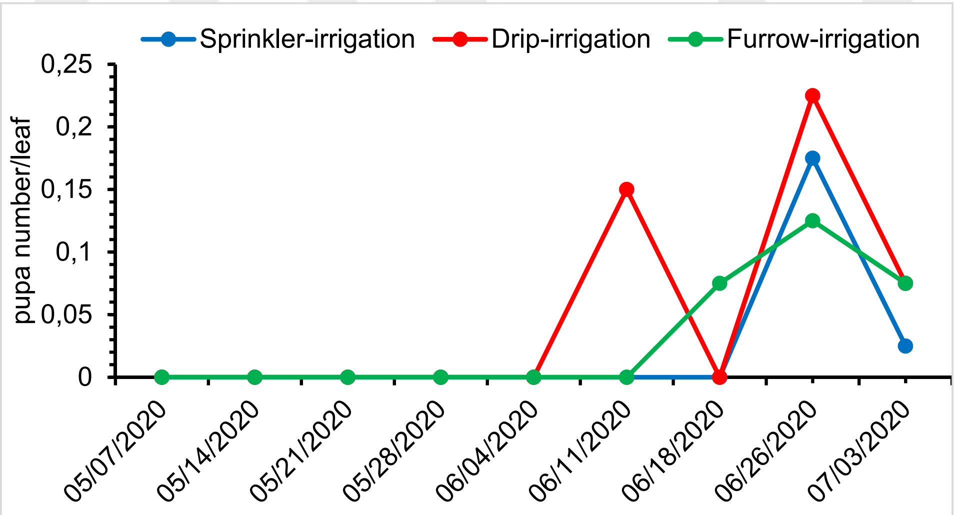


Figure 4.19. Explains the average estimation Leaf miner *Liriomyza trifolii* pupa on the effect of three irrigation systems on the bean culture during 9 weeks in the field

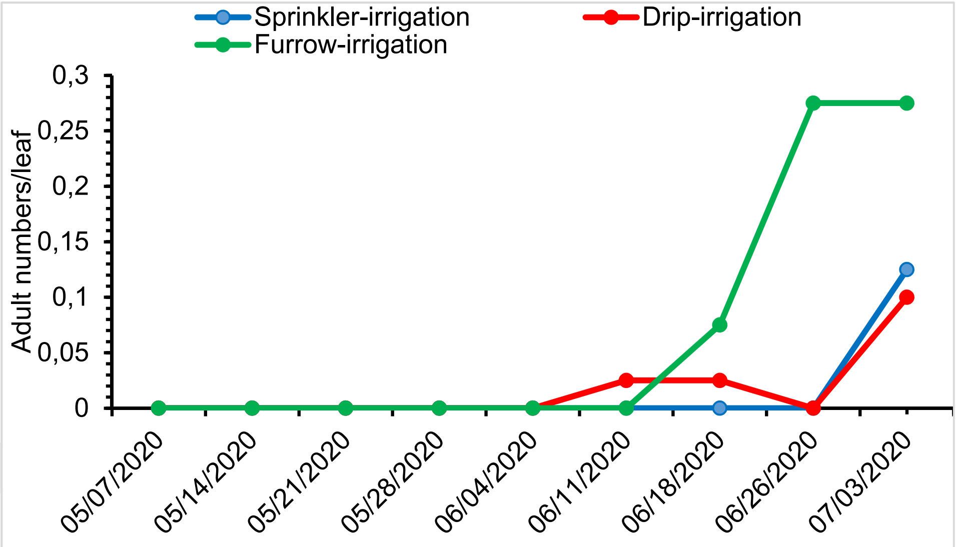


Figure 4.20. Explains the average estimation of Leaf miner, *Liriomyza trifolii* pupa on the effect of three irrigation systems on the bean culture during 9 weeks in the field

Table 4.25. Representative of the total interactions of *Liriomyza trifolii* larvae between the different factors and weeks on the bean

Source	Type III Sum of Squares	df	Mean Square of *L. trifolii* larvae	F	Sig.
Corrected Model	1.250	26	.048	2.336	.000
Intercept	.075	1	.075	3.644	.057
Irrigation systems	.072	2	.036	1.754	.174
Weeks	.367	8	.046	2.227	.023
Irrigation systems * Weeks	.811	16	.051	2.463	.001
Error	21.675	1053	.021		
Total	23.000	1080			
Corrected Total	22.925	1079			

According to General Linear Model results **(Sig.)** indicates significant effects at P = 0.05
R^2= .055 (Adjusted R Squared = .031)

Table 4.26. Representative of the total interactions of *Liriomyza trifolii* Pupa between the different factors and weeks on the bean

Source	Type III Sum of Squares	df	Mean Square of *L. trifolii* adult	F	Sig.
Corrected Model	6.150	26	.237	4.73	.000
Intercept	1.200	1	1.200	24.00	.000
Irrigation systems	.706	2	.353	7.05	.001
Weeks	3.283	8	.410	8.20	.000
Irrigation systems * Weeks	2.161	16	.135	2.70	.000
Error	52.650	1053	.050		
Total	60.000	1080			
Corrected Total	58.800	1079			

According to General Linear Model results **(Sig.)** indicates significant effects at P = 0.05
R^2= .070 (Adjusted R Squared = .047)

Table 4.27. Representative of the total interactions of *Liriomyza trifolii* adult between the different factors and weeks on the bean

Source	Type III Sum of Squares	df	Mean Square of *L. trifolii* Pupa	F	Sig.
Corrected Model	4.207	26	.162	3.06	.000
Intercept	1.268	1	1.268	24.03	.000
Irrigation systems	.146	2	.073	1.38	.250
Weeks	3.191	8	.399	7.56	.000
Irrigation systems * Weeks	.870	16	.054	1.03	.420
Error	55.525	1053	.053		
Total	61.000	1080			
Corrected Total	59.732	1079			

According to General Linear Model results **(Sig.)** indicates significant effects at P = 0.05
R^2 = .105 (Adjusted R Squared = .082)

Table 4.28. Average values of *Liriomyza trifolii* larvae, pupa and adult under the effect of irrigation systems, such as sprinkler-irrigation, drip-irrigation, and furrow-irrigation during 9 weeks on bean plants in the open field

Irrigation systems	*L. trifolii*	N	Mean±SEM
Sprinkler-irrigation	Larvae	360	---------------
Drip-irrigation		360	0.005±0.005
Furrow-Irrigation		360	0.019±0.012
Sprinkler-irrigation	Pupa	360	0.014±0.002
Drip-irrigation		360	0.025±0.010
Furrow-Irrigation		360	0.019±0.004
Sprinkler-irrigation	Adult	360	0.013±0.010 a
Drip-irrigation		360	0.016±0.006 a
Furrow-Irrigation		360	0.069±0.017 b

Significant differences between means ($^{*}P < 0.05$ and $^{**}P < 0.01$) are expressed by different letters (a–b). The letters compare values in the same column.

Table 4.29**.** Anova of *Liriomyza trifolii*. Larvae, pupa, and adult stages under the effect of irrigation systems, between sprinkler-irrigation, drip-irrigation, and furrow-irrigation during nine weeks on bean leaves

Liriomyza sp.		Sum of Squares	df	Mean Square	F	Sig.
Larva	Between Groups	.072	2	.036	1.702	.183
Pupa		.146	2	.073	1.322	.267
Adult		.706	2	.353	6.540	.002

Statistically, the table of ANOVA shows clearly. It exists significant differences in the irrigation systems between larvae, pupa, and adult stages because P-value is less than alfa=0.05

4.1.7. The average number of insect predator in each irrigation systems; such as Predator mites, Predator Thrips, Cecidomyiid, Syrphid, Coccinellid, *Orius* spp, and *Chrysoperla carnea*.

Table 4.30. Average values of some insect predators as mentioned above under the effect of irrigation systems, such as sprinkler-irrigation, drip-irrigation, and furrow-irrigation during 9 weeks on bean plants in the open field.

Irrigation systems	Predators	N	Mean	Std. Dev
Sprinkler-irrigation	*Aeolothrips fasciatus* (black with white bands) (Thripidae)	360	0.025±0.00	0.15634
Drip-irrigation		360	0.036±0.00	0.18683
Furrow-Irrigation		360	0.050±0.01	0.23066
Sprinkler-irrigation	*Amblyseius-swirskii* (Acaridae)	360	0.016±0.00	0.18206
Drip-irrigation		360	0.005±0.00	0.07443
Furrow-Irrigation		360	0.000±0.00	0.00000
Sprinkler-irrigation	*Aphidoletes aphidimyza,* Adult (Cecidomyiidae)	360	0.055±0.01ab	0.31174
Drip-irrigation		360	0.088±0.02a	0.43890
Furrow-Irrigation		360	0.022±0.00b	0.16541
Sprinkler-irrigation	*Episyrphus balteatus* (Syrphidae)	360	0.008±0.00	0.09103
Drip-irrigation		360	0.000±0.00	0.00000
Furrow-Irrigation		360	0.013±0.00	0.13894
Sprinkler-irrigation	*Coccinella septempunctata* (Coccinellidae)	360	0.191±0.05b	0.98141
Drip-irrigation		360	0.627±0.09a	1.7457
Furrow-Irrigation		360	0.138±0.03b	0.63565
Sprinkler-irrigation	*Aphidoletes aphidimyza,* Larvae (Cecidomyiidae)	360	0.116±0.02	0.39881
Drip-irrigation		360	0.136±0.02	0.54932
Furrow-Irrigation		360	0.119±0.01	0.37269
Sprinkler-irrigation	*Orius.* Spp (Anthocoridae)	360	0.050±0.01b	0.23066
Drip-irrigation		360	0.105±0.01b	0.32530
Furrow-Irrigation		360	0.050±0.01a	0.26442
Sprinkler-irrigation	*Chrysoperla carnea* (Chrysopidae)	360	0.025±0.00b	0.17325
Drip-irrigation		360	0.019±0.00	0.13827
Furrow-Irrigation		360	0.030±0.01	0.25126

Significant differences between means ($^{*}P < 0.05$ and $^{**}P < 0.01$) are expressed by different letters (a–b). The letters compare values in the same column.

Table 4.31. Anova table of some insect predators under the effect of irrigation systems, between sprinkler irrigation, drip-irrigation, and furrow-irrigation during 9 weeks on bean leaves.

Insect predators		Sum of Squares	df	Mean Square	F	Sig.
White banded-wing) Thrips *(A.fasciatus)*	Between Groups	3.635	8	.454	13.195	.000
A. swirskii		.174	8	.022	1.693	.096
A.aphidimyza, (adult)		6.783	8	.848	8.418	.000
E. balteatus		.124	8	.016	1.692	.096
C. septempunctata		187.933	8	23.492	17.365	.000
A. aphidimyza, (larvae)		39.291	8	4.911	29.872	.000
Orius. Spp		8.596	8	1.075	15.482	.000
C. carnea		1.983	8	.248	6.925	.000

Statistically, the table of ANOVA shows clearly. It exists significant differences in the irrigation systems between larvae, pupa, and adult stages because P-value is less than alfa=0.05

4.2. Laboratory works

4.2.1. Life table parameters of *Aphis craccivora* and *Aphis fabae* on bean leaves at different temperature regimes

4.2.1.1. Developmental times and Reproductive performances of *Aphis fabae* at five temperature regimes on bean leaves.

The developmental time of *A. fabae* at five constant temperatures is summarized below (Table 4.32). The results showed that the different instar stages significantly decreased with increasing constant temperatures. The first-instar stage ranged from 1.27 days at 20°C to 3.00 days at 12°C and there is no significant difference with 1.55 days at 24°C, 1.70 days at 28°C (F=84.03; P=0.05). For the second instar stage there is significant difference between low and high constant temperature ranged from 1.37 days at 28°C to 3.30 days to 12°C(F=63.68; P=0.05). At the third-period from 1.30 days 24°C to 5.80 days at 12°C, but a slight difference at 28°C with 1.75 days (F=96.65; P=0.05). And at fourth instar stage from 1.52 days at 24°C to 4.55 days to 12°C (F=52.73; P=0.05). Moreover, for the total development time (TDT), the same pattern was presented. The instar stage was shorter at high temperature and longer at low temperature. Significant increase was found for TDT at 12°C and 16°C (16.65 and 11.58 days respectively) compared to 20°C, 24°C and 28°C (6.22, 5.7 and 6.62 days respectively) that are statistically similar(Table.4.32). Concerning the variation days at 28°C treatment. High mortality was observed during immature stages causing a small difference between the results 24°C and 28°C. The pre-oviposition period showed a significance variation between temperature regimes, increasing at high temperature and increased at low temperature (0.27 days at 28°C to 1.10 days to 16°C F=13.54; P= 0.05).

The number of days of oviposition was significantly longer at low temperature, at 12°C it was 23.95 days (F=31.54: P=0.05) and decreased statistically at higher temperature (28°C; 6.67 days) (Table.4.33). The oviposition period was statistically the same for all temperature regimes and ranged from 0.92 days at 16°C to 2.05 days at 20 °C (F=2.09; P=0.05). It was shorter at lower temperature (Table 4.32). Longevity was significantly longer at low temperature (42.33 days at 12°C and 32.6 days at 16°C compared to the others. However, 20°C (22.67 days) was statistically similar to 24°C (20.05 days) and the latter statistically similar to 28°C (16.12 days) (Table.4.33). The life span of *A. fabae* days was significantly longer at low temperature 12°C 25.67days and decreased statistically at higher temperature (28°C 9.50 days F=21.50; P=0.05), (Table 4.33).

Table 4.32. Development times (days Mean±SEM) of *Aphis fabae* on bean (*Phaseolus vulgaris* L.), at five constant temperatures, 65±5% RH, and a photoperiod of 16:00(L: D) h

Temp (°C)	Oviposition (day)	Post-oviposition (day)	Longevity (day)	Life span (day)	Number of offspring (Aphid)
12°C	23.95 ± 0.8a	0.95 ± 0.21	42.32±0.8a	25.67±0.9 a	49.57± 2.6a
16°C	18.87 ± 1.5b	0.92 ± 0.24	32.60±1.6b	21.02±1.5ab	62.27± 5.2a
20°C	14.00 ± 1.3c	2.05 ± 0.45	22.67±1.6c	16.45±1.6bc	55.00± 4.6a
24°C	11.47 ± 1.1c	1.42± 0.47	20.05±1.3cd	14.35±1.3cd	48.67± 4.5a
28°C	6.67 ± 0.8d	2.00 ± 0.40	16.12±1.2d	9.50±1.2d	16.72± 2.5b

Significant differences between means ($^{*}P < 0.05$ and $^{**}P < 0.01$) are expressed by different letters (a–d). The letters compare values in the same column.

Table 4.33**.** Oviposition, post-oviposition, Longevity, life span and number of offspring of *Aphis fabae* adult female individuals (mean ± SE).

Temp (°c)	N1 (day)	N2 (day)	N3 (day)	N4 (day)	Total development (day)	Pre oviposition (day)
12°C	3.00±0.0a	3.30±0.1a	5.80±0.3a	4.55±0.2a	16.65±0.2a	0.97±0.1ab
16°C	2.40±0.1b	3.15±0.1a	2.45±0.1b	3.70±0.2b	11.58±0.4b	1.10±0.0a
20°C	1.27±0.0d	1.57±0.0b	1.80±0.1bc	1.57±0.1c	6.22±0.1c	0.32±0.0cd
24°C	1.55±0.0cd	1.41±0.0b	1.30±0.0c	1.52±0.0c	5.70±0.1c	0.67±0.1bc
28°C	1.70±0.0c	1.37±0.0b	1.75±0.0bc	1.80±0.1c	6.62±0.1c	0.27±0.1d

Significant differences between means ($^{*}P < 0.05$ and $^{**}P < 0.01$) are expressed by different letters (a–d). The letters compare values in the same column.

Virtually at the high level of temperatures, the mother aphids were less survived. The number of newborns per days, their size were reduced and early died at 28°C (Figure.4.19). This study was resulted that with an increasing of constant temperatures, death ratio of the immature populations was more effectively. For example, at 28°C,there is 25% of death compared to the lowest temperature regimes The number of generation are produced per (To) *A. fabae* at 12°C were 29.14 generations while at 28°C 11.50 generations (Table 4.34). The net reproduction (Ro) was higher at 16°C (62.27 aphids/aphid) while at low at 28°C

(16.72 aphids/aphid) (Table.4.34). The offspring per reproduction days was significantly longer at 24°C 4.84 aphids/days compared to others. *A. fabae* at middle temperatures was well developed and showed the highest population growth per capita rate across the intrinsic rate of increase ranged at 20°C and 24°C (0.35 and 0.36 aphids/aphid per days) and the lowest at 12°C (0.15 aphids/aphid per day). The number of offspring was significantly different at 28°C 16. 72 aphids compared to the others.

Table 4.34. Generation time (T0), net reproduction (Ro), and intrinsic rate of increase (rm) of *Aphis fabae* on bean leaf discs at five temperatures levels

Temp (°C)	Sample size(N)	Female adults(N)	Death ratio (%)	Generation time(T_0)	Reproduction rate (R_0)	Offspring per production day (Mean±SEM)	Intrinsic rate increase(aphis/aphid/d)
12°C	40	40	0	29.14	50.96	2.08±0.7b	0.15
16°C	40	36	10	23.17	62.27	2.08±0.1b	0.21
20°C	40	38	5	14.40	55	3.99±0.2 ab	0.35
24°C	40	38	5	12.97	48.68	4.84±0.5a	0.36
28°C	40	30	25	11.50	16.72	2.08±0.3b	0.27

Significant differences between means ($^{*}P < 0.05$ and $^{**}P < 0.01$) are expressed by different letters (a–c). The letters compare values in the same column.

Linear regression was used evaluate the developmental points within the 12 to 24 °C ranged. But the 12 to 28°C of temperature was figured in the linear segment of the growth curve. In the selection of the temperature, the developmental rates of *A. fabae* augmented linearly with diminution of temperature. Development rates of *A. fabae* at the different temperature levels were modelled by linear regression line (y = a ± bx) (Figure 4.18).

Referring to the outcomes of the regression model presented for the data obtained from of *A. fabae*. The development rate equation was found as development rate = 0.0096*Temp.-0.0782 (R2 = 0.4775; P ≤ 0.05) and also for each development stages. Based on these equations, the development thresholds and thermal constants were calculated as shown in (Table 4.35).

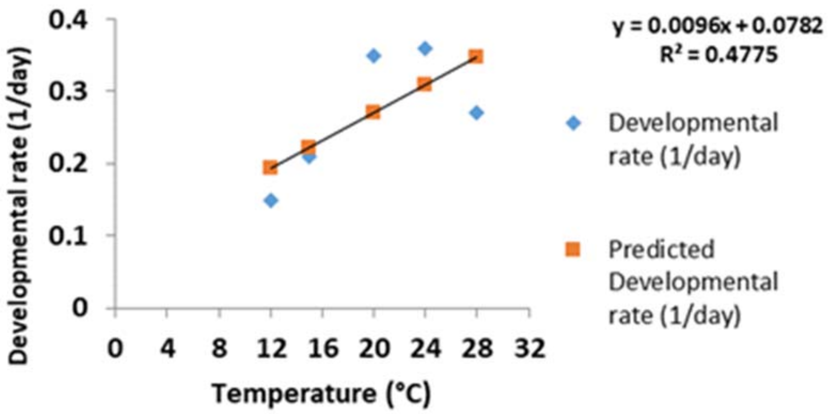


Figure 4.21. Developmental rate (r_m) of *Aphis fabae* at five constant (blue squares) and all of them alternated (variation cycle), analysis of the linear regression line of the developmental rate ranged from12°C to 28°C. The means alternating temperatures were used to calculate the regression analysis.

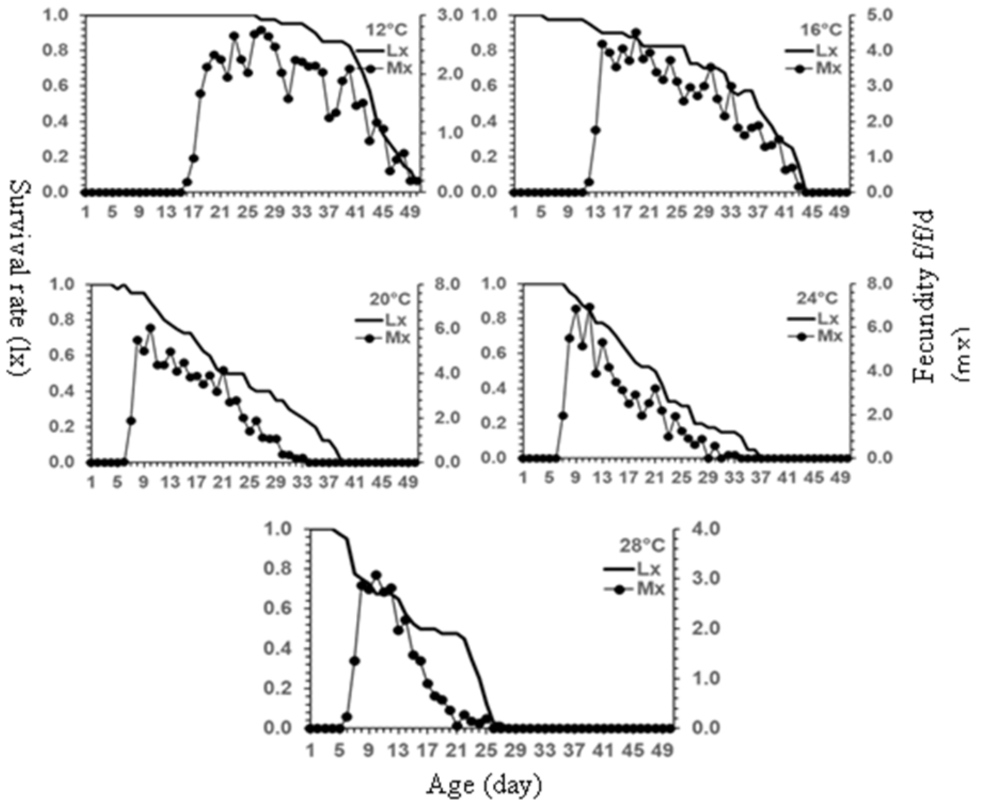


Figure 4.22. Age- specific survival rate (lx) and fecundity (mx) of *Aphis fabae* reared on faba bean leaves *Phaseolus vulgaris* L. at five constant temperatures

Table 4.35. Regression equations and parameters of development rates of *Aphis fabae* on bean leaves under temperature regimes

Parameters	Nymph I	Nymph II	Nymph III	Nymph IV	Adult	Intrinsic rate of increase (rm)
Equation of regression	$y = -0.137x + 4.53$ $R^2 = 0.797$	$y = -0.181x + 5.62$ $R^2 = 0.866$	$y = -0.353x + 9.21$ $R^2 = 0.809$	$y = -0.192x + 6.47$ $R^2 = 0.748$	$y = 0.280x + 7.89$ $R^2 = 0.896$	$y = 0.009x + 0.08$ $R^2 = 0.477$
Thermal constants (1/a) (°C day)	7.30	5.52	2.85	5.20	3.57	8.146
Development threshold (b/a) (°C)	240.9	171.12	74.32	175.18	189.24	848.48

Temperature affects the development as well as growth time; consequently, the evolution and dynamics of insect populations in the field are dictated by ambient temperature. For this reason, there is a considerable interest for a long time in the temperature relationships of development time, reproduction, nymphal mortality rate, longevity, and fecundity of *A. fabae*. The outcomes of this study on the effects of five constant temperatures on the biological development of *A. fabae* are shown previously in the tables. The total development rate of different nymphal stages significantly decreased from 12°C to 24°C with increasing constant temperature, however from 24°C to 28°C of the total developmental was augmented again. This finding was in accordance with some similar studies, (Tofangsazi et al., 2012; Akca et al., 2015). Insect cultured at the temperatures over the threshold develop more slowly than others that were reared below favorable conditions (Satar et al., 1999 and 2005; Kersting et al., 1999). Another observation was made by (Olmez et al., 2003; Maelzer, 1977) who reported that the developmental rate of *Macrosiphum rosae (Hemiptera: Aphididae)* was retarded at temperatures above 25°C to 32°C. This study presented the same reality for *A. fabae* on faba bean at 28°C showing a significant increase in developmental time compared with that at 24°C. Therefore, only at 20°C in the second-instar stage, a slight increase was observed compared to 24°C. The percentage of mortality at 28°C was the highest while at 12°C, the smallest was observed. According to the physiology of *A. fabae*, its adaptation requires more for cold temperatures than high. Although it occurs in tropical areas of Africa, it is not a very serious pest in warm environments (Farhadi et al., 2011). Generally, aphids at lower temperatures need to take more developmental time before they start to produce nymphs (Table 4.32).

Oviposition period of *A. fabae* was clearly showed a decreasing of period of time over the threshold temperature that why it was taken more time for reproducing. For example, it was 23.95 days at 12°C and 6.67 days at 28°C. The post-oviposition period of times did not show any significant differences between the temperatures ranged from the lowest 0.95 days at 12°C to the highest 2.00 days at 28°C (Table.4.33) Longevity and life span from some previous studies reported that decreased constant temperature caused an increasing period. It is a common phenomenon for various aphid species (Morgan et al., 2001; Wang & Tsai, 2000; Barlow, 1962; 2001; Satar and Yokomi, 2002). Another observation was made by Olmez et al., 2003; Akca et al., 2015; Maelzer, 1977 who reported that the developmental rate of *M. rosae* was retarded at temperatures above 25°C. While in our study over 24°C similar results were presented.

The intrinsic rate of natural increase (r_m) is a key indicator that can demonstrate the most favorable temperature level for better population growth because it is estimated from all other indices on the life table of the population. The population reared on temperature from 12 to 24°C had the highest rm- value (r_m = 0.36 aphids/aphid per day) compared with others.

The highest value of rm= 0.36 represents a rapid development and the most offspring reproduction per day with around 4.80 nymphs. And proved as long as rm -value exposed at an alternate of temperature regimes, the number of the newborns per day varies for female of *A. fabae*. For the net reproduction the same alternance was presented with an increasing constant temperature 24°C to 16°C (Ro =48.68 to 62.27). A similar result has been reported by Akca et al., 2015 gradually decreasing from 15 to 25°C (rm=0.43 d-1) While the net reproduction from the lowest to the highest (Ro =77.46 to 90.44) increased. According to those results from the smallest to the biggest the most suitable temperature of *A. fabae* ranged 16 to 24°C, otherwise, its biology can be affected greatly. On the other hand, the host variety also can play a major role in aphid biology. Related by Fernandez-Quintanilla et al., 2002 about a range of life parameters of A. fabae on weed species in winter and summer as 0.14 to 0.36 days (the mean unit used in this article was nymphs per female per days).

4.2.2. Developmental times and Reproductive performances of *Aphis craccivora* at five temperature regimes on bean leaf.

Table 4.36. Development times (days ± SE) of *Aphis craccivora* on bean (*Phaseolus Vulgaris* .L), at five constant temperatures, 65±5% RH, and a photoperiod of 16:00(L: D) h.

Temperature (°C)	n	I. Nymph period	II. Nymph period	III. Nymph period	IV. Nymph period	Total dev.
16°C	40	2.7±0.14a	2.6±0.16a	2.4±0.31a	3.2±0.28a	10.6±0.42a
20°C	40	1.4±0.08b	1.6±0.12b	1.1±0.10 c	1.7±0.17b	6.0±0.30b
24°C	40	1.0±0.00c	1.1±0.04c	1.8±0.07ab	1.4±0.10b	5.2±0.16b
28°C	40	1.1±0.05c	1.0±0.06c	1.5±0.12 bc	1.3±0.12b	5.0±0.17b
Total	160	1.5±0.07	1.6±0.07	1.7±0.96	1.9±0.11	6.7±0.23

Significant differences between means ($^{*}P < 0.05$ and $^{**}P < 0.01$) are expressed by different letters (a–c). The letters compare values in the same column.

Table 4.37. Pre-oviposition, oviposition, post- oviposition, longevity, life span and number of offspring of *Aphis craccivora* adult female individuals on bean (mean ± SE)

Temp (°C)	Pre.Oviposition (day)	Oviposition (day)	Post-Oviposition (day)	Longevity (day)	Life span (day)	Offspring (Aphid)
16	1.17±0.2a	8.95±1.5a	0.25±0.1b	22.2±1.71a	11.6±1.75a	32.1±5.4
20	0.85±0.1ab	6.77±0.9ab	2.05±0.4a	14.1±1.29b	8.1±1.20ab	40.8±6.2
24	0.45±0.1b	6.32±0.4ab	0.42±0.1b	12.4±0.49b	7.2±0.50b	45.2±3.4
28	0.55±0.1b	5.07±0.8b	0.45±0.1b	10.8±0.89b	5.8±0.86b	26.9±4.5
Tot	0.75±0.1	6.78±0.5	0.79±0.1	14.9±0.68	8.2±0.60	36.2±2.53

Significant differences between means ($^{*}P < 0.05$ and $^{**}P < 0.01$) are expressed by different letters (a–b). The letters compare values in the same column.

The pre-oviposition period was significantly longer at 16°C (F=5.02; P=0.05) than all other temperatures, on the other hand, the oviposition period was also longer at 16°C (F= 2.51; P= 0.05) compared with others (Table.4.37). The post- oviposition was significantly increased at 20°C, (F=10.71; P= 0.05) at any other constant temperature tested. Certainly this augmentation is due to the formal adaptation for this temperature for surviving after reproduction time. The longevity shows the same increase at 16°C (F= 17.858; P= 0.05) (Table 4.37). The life span, the same observation was done compared with other temperature regimes. While the highest of offspring days occurred at 24°C (F= 2.74; P= 0.05), despite that, between them, they haven’t presented any statistical differences. (Table 4.37).

Table 4.38. Offspring/day, death ratio (%), wingless adults (n), wing adults (n), generation time (T0), net reproduction (Ro), and intrinsic rate of increase (rm) of *Aphis fabae* on bean leaf discs at five temperature levels

Temp (°C)	N	Offspring (day)	Death ratio (%)	Wingless adults(N)	Wing Adult(N)	(T_0)	(R_0)	(r_m)
16	40	3.6±1.77	20	36	4	22.287	32.175	0.177
20	40	4.2±0.47	25	40	3	13.294	40.850	0.321
24	40	6.5±0.45	5	38	4	13.174	46.975	0.352
28	40	4.1±0.45	20	35	5	10.191	26.925	0.367

The highest average value of fecundity per reproduction day was recorded from 24°C (F= 1.811; P= 0.05). Generally, between the temperatures regimes, there was no statistical differences. Most elevated death ratio was observed at 20°C this issue could be provoked by the vulnerability of the first instar nymphal stage. More wingless adults were observed at 24°C, (Table 4.36). However, at 28°C there were more pterygotes than the others. According to the biological development of the aphid species, at warm temperatures, there is more possibility to develop wings. As indicated at 16°C with the lowest suitable temperatures, aphids can produce more generations.Net reproduction results is the highest quantity of offspring at an optimal temperature, for example, at 24°C, the reproduction increased as well.

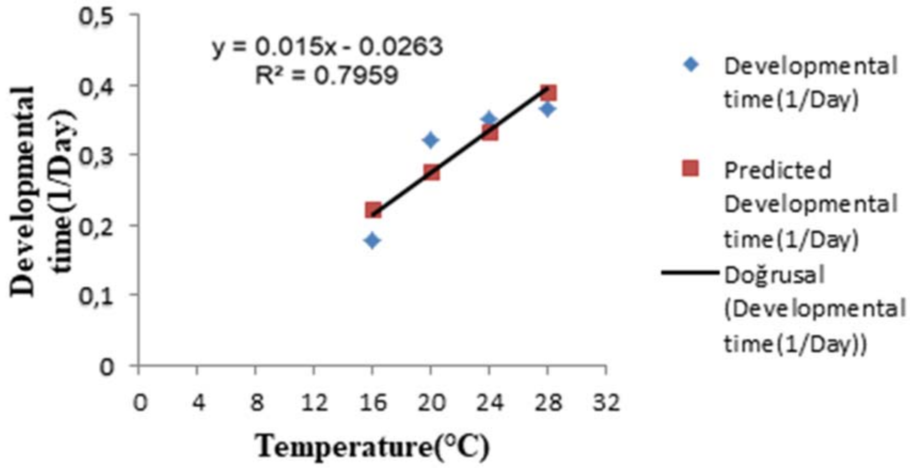


Figure 4.23. Explains the developmental degree day of *Aphis craccivora* at four (4) temperature regimes.

Table 4.39. Regression equations and parameters of development period rates of *Aphis craccivora* on bean leaves under different constant temperatures

Parameters	Nymph I	Nymph II	Nymph III	Nymph IV	Adult
Equation of regression	$y = -0.13x + 4.4$ $R^2 = 0.730$	$y = -0.13x + 4.49$ $R^2 = 0.873$	$y = -0.05x + 2.8$ $R^2 = 0.222$	$y = -0.15x + 5.2$ $R^2 = 0.769$	$y = -0.44x + 16.38$ $R^2 = 0.743$
Thermal constants (1/a) (°C day)	7.69	7.54	20	6.67	2.27
Development threshold (b/a) (°C)	260.08	225.50	1120	231.22	84.51

Developmental rate (r) of *A. craccivora* at four constant temperatures (blue squares; (Figure 4.23) and all of them alternated (variation cycle). Analysis of the linear regression line of de developmental rate ranged between 16-28°C. The mean alternating temperatures were used to calculate the regression analysis. The temperature ranges the developmental rates of A. craccivora augmented linearly with a diminution of temperature. Development rates of *A. craccivora* at four temperature regimes were calculated by linear regression line ($y = a \pm bx$) (Figure 4.23). According to the outcomes of the regression model fitted separately for the data obtained from females of A. craccivora developmental rate. The equation of females was found as a developmental rate equals to 0.015*Temp.-0.0263 ($R2 = 0.97$; $P \leq 0.05$) from the first instar to adult stage and development. By these equations, the development of thresholds and thermal constants was calculated.

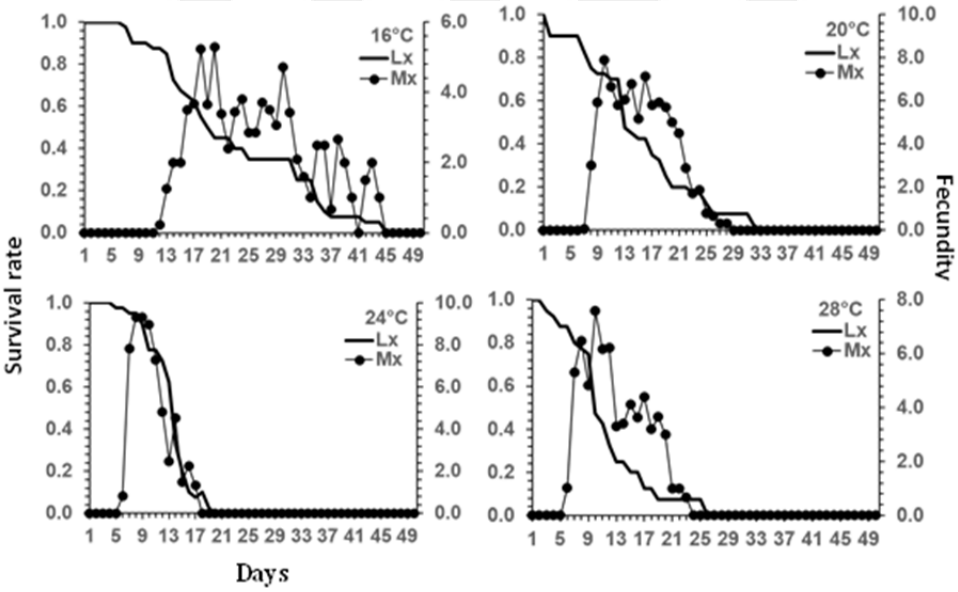


Figure 4.24. Age- specific survival rate (lx) and fecundity (mx) of *Aphis fabae* reared on faba bean leaves (*Phaseolus Vulgaris* L.) at four constant temperature

Aphid species as small ectothermic animals, they have an undeniable relationship with temperature. Recall that temperature influences multiple aspects of insect biology, from metabolic and developmental rates to the timing and level of insect activity. It also affects insect survival. Temperatures beyond the thresholds of development for a given insect can slow growth, and extreme temperatures can kill members of an insect population. It is logical then to expect that temperature fluctuations can cause changes to insect biology. In this study, we discuss how temperature alternatives affect insect biology. Some biological parameters of *Aphis craccivora* are discussed. In this study, the maximum temperature for the development of *A. craccivora* was 28°C (table.4.35), (mean=6.7; F=81.78; P=0.05), but there are lots of reports at 30°C (Cho et al., 2018, Kuo and Chen, 2004),and 29.4°C Berberet et al., 2009, Girão Filho et al., 2019) on faba plants. The approximated results are well-established with the degree of the temperature in which ectothermic animals that develop under warm conditions tend to grow faster, mature earlier. On the other hand are slower in maturation compared to similar animals that develop under cool conditions. The pre-oviposition period of times with a gradual decreasing constant temperature augments the duration of times before appearing fecundity. For example, from the lowest 16°C to 24°C was similar to that reported at 16 and 25°C by (Cho et al., 2018), Girão Filho et al., 2019). The quantity of oviposition days depends greatly on the area in which the insect is evaluated by using food and weather resources. Normally at both lowest and higher tolerated temperatures, insect can take a long time for reproducing having as an example, from 16°C to 28°C, (mean=8.95, 5.07; F=2.519; P=0.05), respectively. The same tendency at 15, 20, 25°C is reported by Cho et al. (2018), and 18, 22, 25, 28°C by Girão Filho et al. (2019).

The Post-oviposition period times at 16°C (mean=2.05; F=2.519; P= 0.05) if it is below the lowest relative temperature for good reproduction in effect, the time after the offspring period becomes longer than the adaptive temperatures that reported at 18, 22, 25, and 28°C by (Girão Filho et al., 2019) respectively, (days±SE 1.2, 0.8, 0.8, and 0.2). The longevity increases with the diminution constant temperatures inversely decreases with their augmentations as we can see from 16°C to 28°C respectively (Mean/days±SE), 22.2 to 10.8) the same process reported from 18°C to 28°C(Mean/days±SE), 11.5 to 6.8) by (Girão Filho et al., 2019).

Although there was differences between the results presented in this research within the life span of *A. craccivora*, the alternation of temperatures is shown to have some significant differences between them with increasing number of days from the highest to lowest, 28°C and 16°C (Mean/days±SE) 5.8, 11.6, F=4.340; P= 0.05), respectively (Table.4.36). The interrelation of the temperatures through the life span, when compared to the number of days, we observed similarities within them, the lowest at 16°C to highest at 28°C. It was noticed that there were not any significant differences.

Those involve that to the range of these temperatures there are accessible for good survival for aphid species. (Table 4.37). In general, these observations established the inverse proportional relationship within oviposition periods and immature stages produced per female per day in the thermal range of 16 to 28ºC, compared to the results presented by (Berberet et al. 2009 and Girão Filho et al., 2019).

According to the results suggested, there is a lot of possibilities for adaptation between several studied aphid populations. For example, the variations observed on thermal constants development based on the suitable temperature for black-aphid on the bean might be explained in part about the functional theory of its life which relates with the highest value for a development threshold and the smallest value for total thermal requirement as expected for species more adapted to the tropical regions and also temperate regions (Trudgill; Perry, 1994; Trudgill, 1995).

5. CONCLUSION AND RECOMMENDATIONS

This research was conducted on two levels of studies, first one was realized in the field at Plant Protection Department of Cukurova University in Adana in the goal to study the effect of three irrigation systems, such as sprinkler, drip, and furrow irrigation under the evolution of some insect pest populations, beneficial insects on bean, and its yield parameters, in which;

- *A. fabae* (Hemiptera: Aphididae) nymph and adult stages
- *B. tabaci* (Hemiptera: Aleyrodidae) egg, larvae, and adult stages
- *E. decipiens* (Hemiptera: Cicadellidae) larvae and adult stages
- *T. tabaci and F. occidentalis* (Thysanoptera: Thripidae) larvae and adult stages
- *T. urticae*,(Acarina: Tetranychidae).Eggs, nymphs, and adult stages
- *L. trifolii* (Diptera: Agromyzidae), Larvae, pupa, and adults

  Predator insects;
- *C. septempunctata*: (Coleoptera: Coccinellidae)
- *C. carnea* (Neuroptera: Chrysopidae *)*
- *Orius* spp (Hemiptera: Anthocoridae)
- *A. fasciatus* (Thysanoptera: Thripidae) (black with white bands Thrips)
- *A. swirskii* (Acarina: Phytoseiidae)
- *A. aphidimyza* (Diptera: Cecidomyiidae)

According to the finding results from drip-irrigation that concern the evolution of the pest populations, more particularly, *A. fabae* was demonstrated a considerable loss of yield for that reason, this system wasn't appropriated for bean plantation in opining areas.

Sprinkler and furrow-irrigation were stabilized-well the pest population around an economic threshold acceptable by the physical action exercised the sprinkler system all over the part of the plant. They were allowed good growth and development of bean production and trichomes density under the surface of leaves that severe as a barrier at the attacks of sucking-piercing part mouth. *A. fabae* and *A. craccivora* on the effect of different constant temperatures

As well as temperature, precipitation, and humidity can influence the life table of insect pests, predators, parasites resulting in a complex dynamic of interaction constant for surviving. For example, fungal pathogens of insects are favored by high humidity incidence which could be increased with climate change that lengthens periods of high humidity and reduced by those that expose in drier conditions. Some insects are sensitive to precipitation and are killed or removed from crops by heavy rains, this technic is important by choosing management options for onion Thrips and other pests (Reiners and Petzoldt, 2005)

In the laboratory of citrus pest, we experimented also five thermal constant temperatures on growth and development times of *A. fabae* and *A. craccivora* on the bean. According to the outcomes

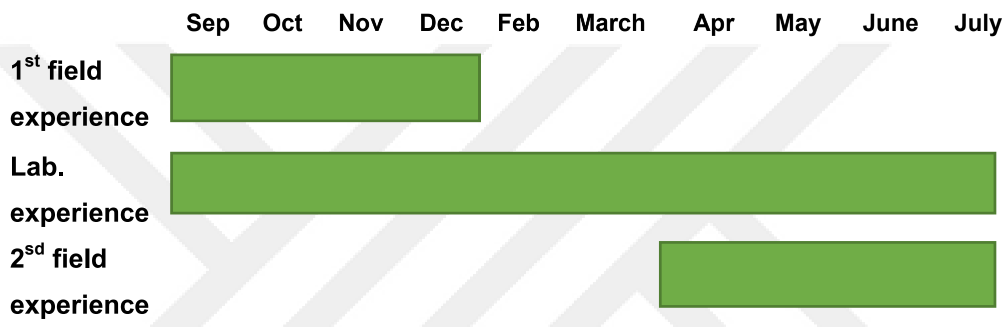
1- *A. fabae* under different constant temperature presents the fastest development at 20 and 24°C with a rate of 5% of nymph mortality, while at the lowest 16°C present 10% and highest 28°C (25%). This species adapts more in cool areas for surviving.
2- *A. craccivora* on the effect of the different constant temperature regimes results at 24 and 28 °C develops more rapidly with mortally rate of 5% and 20%, respectively. This aphid like more the middle temperature for its life cycle, yet more than 28°C can decrease its biological performance.

   Recommendations,

   a. This study did not take into consideration all the technical itineraries of bean plantation, for example, the use of fertilizers that is why the yield production was low. And then a lot of vegetative parameters were measured. In this case, these concepts are recommended for a future research.

b. According to our diverse observations between the irrigation-systems. The sprinkler and furrow irrigation could be used for bean production

Work schedule



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BIOGRAPHY

I was born in Haiti particularly at Milot, and studied primary school at Ecole Sainte-Croix de Thibeaux, professional school, Salesian Don Bosco (Cap-Haitian), and high school at Lycée national Phillipe Guerrier (Cap-Haitian). I licensed in agriculture General sciences at North Haiti Christian University (UCNH), started in 2010, and graduated in 2015. I worked for two years at the smash/papyrus project at the port- au- prince 2015-2017. During this year, I won a Turkish government scholarship at the Cukurova University at Graduated School of Natural And Applied Sciences for studying a Master's degree in Department of Plant Protection (Entomology) and finished in October 2020.

ÖZGEÇMIŞ

Haiti'de özellikle Milot'ta doğdum ve ilkokulu Ecole Sainte-Croix de Thibeaux'da, meslek okulunu Salesian Don Bosco'da (Cap-Haitian) ve Ulusal lisede (Lycée Phillipe Guerrier'de) (Cap-Haitian) okudum. Kuzey Haiti Hristiyan Üniversitesi'nde (UCNH) tarım Genel bilimleri lisansı aldım, 2010'da başladım ve 2015'te mezun oldum. 2015-2017 yıllarında SMASH/PAPYRUS projesinde iki yıl çalıştım. 2017 yılında, Çukurova Üniversitesi'nde Türk Hükümeti Bursunu kazandım. Bitki Koruma Bölümü Entomoloji alanında yüksek lisansa basladim. 2020 Kasimda Fen Bilimleri Enstitusunden mezun oldum.