Sudan University of Science and Technology

College of Graduate Studies and Scientific Research

Integrated Management Approach of Yellow Leaf Curl Virus Disease in Tomato (*Lycopersicon esculentum* Mills.)

طريقة الادارة المتكامله لمرض فيروس تجعد واصفرارالاوراق في الطماطم

A thesis submitted in partial fulfillment of the requirements for the M.Sc. Degree in plant protection.

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الايه

بسم الله الرحمن الرحيم

قال تعالى:

(أفرأيتم ما تحرثون *أأنتم تزرعونه أم نحن الزارعون*) صدق الله العظيم

(الواقعه 63،64)

Dedication

To My Kind Mother

To My Husband and Lovely Daughter Mishcat

To My Brothers and Sisters.

To My Friend s

With My Love to all.

Acknowledgement

I wish to thank the merciful My God who offer me strength and high spirit to perform this study in satisfactory form .My thanks first to Ministry of Agriculture for given me chance of this Master graduate. Moreover, my way towards this Master thesis wouldn't have been possible without the help and support of some people, so it is my pleasure to take this opportunity to thank all of them. First and foremost, I'm honored to express my deep gratitude and datedness to my supervisor Dr. Ibrahim Saeed Mohamed, for the voluble support, criticism and close supervision. Especial thanks are due to Syngenta Agrosericvice, Country Representative Office (CRO) - Sudan. More thanks due to Dr.Tagelsir .Idris, for his assistance and support for available the land for experimental work. Thanks are also due to my collegues in faculty of agriculture department of plant protection in Sudan University of Science and Technology.

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ABSTRACT

Tomato is considered as one of the most important vegetable grown worldwide. Many disease effect tomato and cause severe damage the most one which suffers important losses is tomato yellow leaf curl virus disease. The aim of this study which conducted in winter season 2013-2014 was to evaluate the integrated effect of covering tomato seedlings with mosquito net, use of different tomato varieties, application of Argil as foliar and in soil and frequent spraying of synthetic pesticides on incidence and severity of Tomato Yellow Leaf Curl (TYLCV) disease transmitted by white fly (*Bemisia tabaci*). The study revealed that covering of the tomato seedlings with mosquito net at nursery for six weeks before transplanting to the field resulted in healthy and vigorous seedlings with high plant population compared to control. The combined effect of treatments (covering tomato seedlings in nursery, Argil applications and chemical spray) and varieties resulted in significant decrease of TYLCV incidence covered+argel foliar inVT60788 variety (0%), covered+argel soil inVT60788 variety (11.1%), chemical spray inVT60788 variety (11.1%), covered+argel foliar in Omdurman variety (11.1%) and covered+argel soil in Omdurman variety (0%) and severity values covered+argel soil inVT60788 variety and chemical spray inVT60788 variety (0%) and compared to control (25%). The increase in TYLCV incidence and severity (83.3 – 91.7) towards end of experiment attributed to the high inoculums pressure in Shambat area. This necessitates growing of tomato in relatively isolated disease free fields. The findings of this study highlighted the importance of integrating different disease management approaches for controlling TYLCV disease incidence and severity rather than use of one single approach.

ملخـــص البـحـث

تعتبر الطماطم من اهم الخضروات التي تزرع في علي نطاق العالم . تصاب الطماطم بالعديد من الامراض التي تؤدي الي خسائر كبيره في الانتاجيه ويعتبر مرض تجعد اوراق الطماطم من اهم هذه الامرض .

اجريت هذه الدراسه في الموسم الشتوي (2013-2014) بهدف تقييم الاثر المتكامل لتغطية بادرات الطماطم بقماش الناموسيات،استعمال اصناف طماطم مختلفة ،اضافة الحرجل الي التربة ،رشه على الاوراق وايضا الرش المتكررللمبيدات علي درجة وشدة الاصابة بمرض تجعد اوراق الطماطم الفيروسي الاصفر المنقول بواسطة الذبابه البيضاء. اوضحت نتائج هذه الدراسه ان عملية تغطيه بادرات الطماطم بالمشتل لمدة ستة اسابيع قبل نقلها الي الحقل ادت الي نمو بادرات صحيه وباعداد كبيره مقارنة بالشاهد. كما وجد ايضا ان التأثيرالمشترك للمعاملات من تغطية للبادرات في المشتل واستعمال الحرجل والمبيدات ادي الي خفض نسبة الاصابه بمرض تجعد وراق الطماطم بصورة معنويه (0%) التغطيه مع الرش بالحرجل للصنف VT60788، (11.1%) التغطيه مع اضافة الحرجل في التربه للصنف VT60788،(11.1%) المعامله بمبيد الفوليمات للصنف VT60788، (11.1%) التغطيه مع الرش بالحرجل للصنف امدرمان(0%)التغطيه مع اضافة الحرجل في التربه للصنف امدرمان. كذلك الي خفض حدة المرض (0%) التغطيه مع اضافة الحرجل في التربه للصنف VT60788. و(0%) المعامله بمبيد الفوليمات للصنف VT60788 مقارنة بالشاهد(25%).

ان ذيادة نسبة الاصابة وحدة المرض في نهاية التجربة يعزي الي ارتفاع نسبة اللقاح بمنطقة شمبات الامر الذي يستدعي زراعة محصول الطماطم في مناطق غير مأهوله بالمرض او خاليه منه نسبيا.

نتائج هذه الدراسه القت الضوء علي اهمية الادارة المتكاملة باستعمال عدة منهجيات لمكافحة مرض اصفرار وتجعد اوراق الطماطم الفيروسي بدلا من استعمال منهج واحد.

CHAPTER ONE

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mills.) is one of the most popular important commercial vegetable crops grown worldwide (Prior *et al.*, 1994). The production estimate worldwide was 95 million Mt annually (FAOSTAT, 2002). Many destructive pathogens of both greenhouse and field grown tomatoes in warm vegetable production areas such as the tropics diseases and disorders affect tomatoes during the growing season (Peralta *et al.*, 2001).

In Sudan tomato is becoming increasingly important for local consumption as the crop is rich in vitamins A, B, and C and for export. The crop is cultivated throughout the year under an area that exceeds 43453 hectares yielded an average of 484000 metric tons annually (FAO, 2005/2006). The most important grown cultivars are the canning Types such as Strain B, Strain C, Peto86, Peto111 and Castle Rock in addition to few local varieties (Marmar *et al.*, 2009).

Among Virus diseases, tomato mosaic and tomato Yellow leaf curl viruses are considered as the most important ones.

In fact, Tomato Yellow Leaf Curl Virus (TYLCV) disease is one of the most devastating begomovirus infecting cultivated tomatoes in tropical and sub tropical regions. Whitefly *Bemisia tabaci*, (Homopetra: Aleyrodidae) is an important insect pest which causes direct feeding damage, as well as indirect damage as vector of numerous geminiviruses such as TYLCV which is a threatening virus for tomato production (Delatte *et al.*, 2005). *Bemisia tabaci* beside its role as tomato leaf curl virus disease vector also excretes honey dew. This sweet and sticky excrete substances attracts both saprophytic fungi and ants, the potential dispersal agents of fungal spores (Yassin *et al*; 1990). Tomato leaf curl virus disease of tomato has been managed primarily by the use of resistant varieties (Bhatia *et al.*, 2004). However, breakdown in resistance of these varieties due to evolution of virulent races of the pathogen have undermined their importance in recent years (Jiménez-Díaz, *et al.*, 1993).Moreover, insecticides were considered indispensable for sustainable agriculture production but, their increasing and irrational use has become a source of great concern because of their possible effect on human health and non-target components of the environment. This concern is heightened by the non-specificity and high toxicity of some pesticides and development of resistant strains of microorganisms against other ones. The foregoing has initiated the exploration of safe alternate antimicrobial agents (Ali, 1996). Historically, more than 1000 species of plants have been reported to have chemicals in leaves, stems, flowers, seeds and roots which have insecticidal proper only a few of them have been used for insect control on commercial scale (Badshah *et al.* 2004).Examle of these plats are Argel. The bioactivity of this plant were mainly attributed to the presence of varieties of bioactive organic substances mainly terpenes pergenine glycosides alkaloids and sterols (El-kamali 2001; and Sidahmed *et al,.* 2009. Thus the chemical poisons of argel plant (*Solenostemma argel* Del Hyne) are mostly alkaloids (Al-

Doghairi *et al.*, 2004) which are nitrogenous in nature and they are heterocyclic compounds having strong effects on the nervous system of organisms and causing death (Badshah *et al.* 2004). Integrated management strategies are the only solution to maintain plant health. These strategies should includes use of resistant varieties, minimum use of chemicals for checking the pathogen population, modification of cultural practices and use of safe alternate antimicrobial compounds of higher plants.

Based on the foregoing, this study was aimed to investigate the following:

- To study the effect of covering tomato seedlings practice on control of white fly (*B. tabaci*) vector of TYLC disease;
- To evaluate tomato cultivars for resistance or tolerance to the disease;
- To explore the potentials of Aarjal plant applications in reducing the incidence of the disease;
- To evaluate the effect of frequent spraying of tomato with synthetic insecticides.

CHAPTER TWO

LITREATURE REVIEW

2.1. Tomato

Tomato (*Lycopersicon esculentum* Mills.) It was described by Hansen, (2000), as an ancient vegetable crop which originated in Peru, South America. It was then taken to Europe by the earlier invaders and from there to North and South America and the rest of the world.

In the Sudan it is the Second most important vegetable crop after onion. It is cultivated in wide area around large Cities along the Nile and on seasonally flooded plains. Tomato can be grown throughout the year in different parts of the country, provided that the temperature is suitable for fruit setting (FAO, 1999).

2.1.1 Tomato production in Sudan :

The main producing areas of tomato in Sudan are Gazera

Scheme, Khartoum, Blue Nile, White Nile and Kassala States. The crop is also produced in Jabl Marra and some part of the main rain fed areas around Villages, central clay plains and utilized as sun dried slices. Summer production of tomato is practiced in limited areas in Blue and White Nile and Khartoum States as it ensures High profitability because of the scarcity of the crop at time (FAO, 1999). It is recently produced under controlled green houses during summer season and this practice is extending rapidly every year.

2.1.2 Nutritive value of tomato :

Tomato is classified as group 2 on food production efficiency. It comes after squash in the list of vegetables. The food value content of tomato can be, Summarized as follows : -

Water	93.5 %	
Potassium	0.244 %	
Phosphorus	0.27 %	
Ascorbic acid	0.023 %	
Calcium	0.013 %	
Iron	0.0005 %	
Carbohydrates	4.7 %	
Proteins	1.2487 %	
Amino acids	0.00080 %	(Mahmud, 1984)

2.1.3 Botanical characteristics:

Tomato has Avery extensive roots system and in some varieties may extend up to six feet and even to the depth of 10 to 12 feet. Adventitious roots are produced from the main roots if is set deeper at Trans planting time. Sometimes numerous lateral branches develop from the axils of the leaves on the main stem resulting in bushy plant. Leaves are alternate and compound on garden varieties and there are about 14 --- 18 flowers / plant.

Tomato fruits may be globe shaped or almost round oval or flat ended and pear shaped, while most of the varieties of commercial importance are red scarlet, a few are pink (Viygred.1980)

2.1.4. Classification

Kingdom:	Plantae
Sub kingdom:	Tracheobionat
Division:	Mangoliophyta
Class:	Mangoliopsida
Sub class:	Asteridae
Order:	Solanales
Family:	solanaceae
Genus:	Lycopersicon
Species :	esculentum (smith, 1994)

2.2 Pests and diseases:

Numerous pests and disease were known to attack tomato, of which the viral, bacterial and the fungal diseases are the most important (Yassin and Nour, 1965 b). This is due to the nature of tomato plant canopy and its long life span in the field (Abu sin, 1994).

2.2.1 Insects pest:

Many insects are attacking tomato e.g. White fly, Aphides, Boll worms, leaf miners and other. Which are causing damage resulted in considerable reduction of yield.

2.2.2 Diseases:

Among virus diseases, tomato mosaic and tomato Yellow leaf curl viruses are considered as the most important ones. Bacterial diseases include bacterial wilt (*Pseudomonas Solanacearum*),bacterial canker (*Corynebacterium michiganense*) and bacterial speck (*Pseudomonas Syringae*). Major fungal diseases are Fusarium wilt (*Fusarium oxysporum f. sp. lycopersici*), Verticillium Wilts (*Verticillium dahliae*), powdery mildews (*Leveilula Taurica*) and early and late blights, which are caused by *Alternaria solani/ alternata* and *Phytophthora infestans*, respectively (Marmar, *et al.*, 2009).Tomato is attacked by different varieties of fungi causing significant reduction of production and serious damage such as powdery mildew and wilt.

2.3 Tomato Yellow Leaf Curl Virus Disease:

2.3.1. Historic perspective

Plant viruses, like all viruses, are obligate intracellular parasites that do not have the molecular machinery to replicate without a host. During the 1960s a new disease reported in the Jordan valley in Israel caused severe damages to a newly introduced tomato variety to the market. This disease was later called tomato yellow leaf curl disease

(TYLCD) (Cohen and Nitzany, 1966). Tomato yellow leaf curl virus (TYLCV) was found to be the causative agent of this disease and was associated with outbreaks of the whitefly *Bemisia tabaci* populations nearby cotton fields, which were newly grown in this area. These cotton fields helped *B. tabaci* populations to build up to high levels, and outbreaks of the disease were seen afterwards.

Although symptoms of TYLCD on plants were observed as early as the 1930s but outbreaks of the disease were not observed until *B. tabaci* populations greatly increased. Tomato yellow leaf curl virus was observed as having geminate shape in 1980 (Russo *et al.,* 1980), and a few years later the viral genome was fully cloned and sequenced, and the virus was shown to be a monopartite geminivirus (Navot *et al.*, 1991). Since the late 1990s research regarding TYLCV focused on understanding the interactions between TYLCV, plants that it infects, and its only vector, *B. tabaci.*

2.3.2. The Economic Importance of the Disease

Tomato yellow leaf curl virus disease is a major problem affecting tomato production in many of the old world, tropical and subtropical countries. Field cropping of tomato in the coastal plains of Lebanon stopped because of TYLCV (Abu Jawdah & Shebaro, 1993). Whenever TYLCV is introduced into a new country where the vector is already present, it usually spreads rapidly throughout the commercial tomato crops. In places like Mediterranean regions, the incidence of this viral disease is especially important in summer and autumn crops after periods of high temperatures and relative humidity (RH) suitable for vector development (Polizz and Areddiam, 1992). Moreover, in Israel (1939-1940) TLCV associated with outbreaks of *Bemisia tabaci* and the entire tomato crop was destroyed by the disease in Jordon valley (Cohen and Antigeus, 1994).

The disease is known to occur wherever tomato is growing in the Sudan. Giha (1996) reported that the disease is often found to occur in an epidemic level, causing reduction in fruit yield amounting to 75% or more. In many areas TYLCV disease has become one of the main factors limiting tomato production in both outdoor and in protected crops .The incidence, severity and spread of the disease are significantly correlated with the fluctuations in the population of vector (Loannon, 1985 and Cohen 1988).

2.3.3 The Causal Organism and Host Plant

Tomato yellow leaf curl virus (TYLCV) (Begomovirus, Geminiviridae) is the type member and representative of the complex of viruses associated with the tomato yellow leaf curl disease (TYLCV) with ssDNA genome, a plant-infecting group of viruses that have single or double genomic components enveloped by an icosahedra coat protein. These viruses infect Tomatoes and other vegetable and ornamental crops and cause severe losses estimated by billions of dollars each year. Begomoviruses are exclusively transmitted by the whitefly *Bemisia tabaci* in a persistent circulative manner. Epidemics were often associated with the presence of whiteflies. Since then, extensive research in many laboratories in the world was conducted to better understand the interactions between TYLCV, the tomato plant and its only vector B. tabaci. These studies resulted in hundreds of research papers and reviews, and in creating new research disciplines unraveling geminiviruses and their interactions with plants and whiteflies.

2.3.4. Vector and biology

Whiteflies are pests which affect agricultural crops and ornamental plants, both in greenhouses and outdoors, and are vectors of many viruses. The tobacco whitefly *(Bemisia tabaci* Genn.) is the insect vector of tomato yellow leaf curl virus (TYLCV), a geminivirus with a single genomic component (Czosnek *et al.,* 1988a; Navot *et al.,* 1991). The TYLCV known to affects tomato crops *(Lycopersicon esculentum* Mill.) In the Middle East and in many other tropical and subtropical regions (Czosnek *et al.,* 1990).

The virus is transmitted by *Bemisia tabaci* (EPPO/CABI, 1996a) in a persistent manner. Biotype B is usually the form of *B. tabaci* involved (Mehta *et al.*, 1994) which transmits the virus with high frequency (McGrath & Harrison, 1995). Acquisition and inoculation feeding periods range from 20 to 60 minutes and from 10 to 30min, respectively, depending on the isolates (Ioannou, 1985; Mansour & Al-Musa, 1992). The latent period of the virus inside the insect is 20-24 h. and can persist in the vector for 10-12 days and only rarely for up to 20 days. No transovarial transmission of the virus has been found. Nymphs can acquire the virus and transmit it when they reach the adult stage. The phenomenon of periodic acquisition has been established, by which the ability to reacquire the virus and resume infectivity is possible only after total loss of infectivity. However, most whiteflies lose their ability to transmit the virus within 10-12 days after an acquisition period of 24-28h (Mansour & Al-Musa, 1992).

2.3.5. Symptoms of tomato yellow leaf curl disease

Severely attacked tomatoes by the disease are easily recognizable in the field and the new growth of plants with Tomato yellow leaf curl has reduced internodes, giving the plant a stunted appearance (Yassin and Nour, 1965a). The new leaves as well are greatly reduced in size, wrinkled, 1and yellowed between the veins and have margins that curl upward giving them a cup-like appearance. Flowers may appear but usually will drop before.

2.3.6. The Effects on Yield

Tomato plant are susceptible to TYLCV disease at all stages of their growth (Saikia and Muniy-appa,1989), but yield reductions were determined to a great extent by the stage at which tomato plants become infected. Yield losses caused by TLCV vary between 50% and 82% depending on the strain of the virus, the tomato cultivar and the growth stage at which plants become infected (Loannou, 1985a). Yield losses of 100% are common, particular when plants are infected at early stage of development (Cohen and Antignus, 1994;

Nakhla and Maxwell, 1998). In Gezira , central Sudan, it was reported that the virus incidence results in more than 70% yield reduction and even causes losses up to 100% in tomato in tropical, subtropical regions (Ahmed *et al.*, 2001).

2.4. Management Approaches

Several methods have been developed to control TYLCV, such as the use of healthy transplants, chemical and physical control of the vector, crop rotation, and breeding for resistance to TYLCV (Nakhla & Maxwell 1998). The most effective and environmentally sound management remains planting of resistant or tolerant varieties. Thus, breeding for TYLCV resistance is probably the most important long term goal for lasting TYLCV management (Lapidot and Friedmann, 2002). At present, only partially resistant Fl hybrids are commercially available. Moreover, a prevalent Problem is associated with the definition of resistance. As stated by Lapidot and Friedmann (2002), a host plant is resistant to TYLCV if it can suppress its multiplication and consequently suppress the development of disease symptoms.

Lower virus accumulation in a resistant host has been associated with the latter's resistance, as well as with the effect of infection on total yield and yield components (Lapidot *et al.* 1997). Classical breeding has attempted to introduce TYLCV resistance in tomato cultivars. However, resistance appears to be controlled by one to five genes and crosses have produced only tolerant hybrids which is unfortunate after over 25 years of breeding.

Moreover, the best commercially available cultivars show only tolerance to the virus and mean while, the disease continues to spread. Therefore, the production of transgenic tomato plants appears to be a more promising way of obtaining resistance to TYLCV. Several strategies have been used to engineer plants resistant to viral pathogens, based on the concept that the introduction and expression of viral sequences in plants can interfere with the virus's life cycle. This strategy is also referred to as pathogen derived resistance (Lapidot *et al.* 1997).

2.4.1. Avoidance

2.4.1. a. Avoidance in time

Planting dates or locations that avoid high whitefly populations will often have a significant impact on incidences of TYLCV-infected plants. In addition, planting during these times can significantly increase the impact of the management tactics and may reduce the costs associated with them. In Israel, processing tomatoes are transplanted to the field in early spring, usually the end of March or the beginning of April, and are harvested 3 months later. In Israel, TYLCV spreads mainly during the late summer and autumn due to whitefly populations which peak from September to November. Processing tomatoes are harvested prior to the buildup of large whitefly populations when incidences of TYLCV-infected plants are lower. When TYLCV appears late in the plants 'development, impact on yields are minimal.

2.4.1. b. Avoidance in space

New plantings should not be located near old plantings. New tomato plantings should not be placed near any crops known to be hosts of TYLCV nor should they be located next to older fields of tomato, older fields of known susceptible crop species or any crop species where whiteflies are not managed. This is especially true of resistant tomato cultivars which may not show symptoms but may still act as sources of TYLCV for susceptible cultivars (Lapidot *et al.,* 2001).

2.4.2. Plastic mulches

In open field production in Florida, reflective plastic mulches are used successfully to reduce incidences of TYLCV-infected tomatoes. The most effective reflective mulches are entirely or partially aluminized and reflect a lot of daylight. These are believed to reflect both visible and UV light which disorients whiteflies and decreases the landing of whiteflies on plants in the field. Like other mulches, the effectiveness decreases as the tomato canopy increases and covers the mulch.

Reflective mulches are effective even when whitefly populations are expected to be high. This approach has the added benefit of interfering with other virus vectors (aphids and thrips) and is associated with lower incidences of several other tomato viruses.The use of yellow plastic mulch to protect open-field tomato plants from the whitefly-borne TYLCV is a common practice in Israeli agriculture (Zaks, 1997) . Interestingly, yellow plastic mulches were not found to be effective in Florida (Csizinszky *et al.,* 1996, 1999). The reason for this may be due to the very high level of humidity in Florida. Whiteflies which are attracted to the yellow mulch probably are not dehydrated as quickly in Florida as they were in Israel, where relative humidity is much lower. Whiteflies attracted to the yellow mulch in Florida were still able to fly to a plant and feed on it. In a climate with high relative humidity the yellow mulch may actually attract whiteflies to the crop rather than protect it from whiteflies. Although the yellow plastic mulches were ineffective in Florida, reflective or aluminized plastic mulches have been used very successfully to reduce incidences of TYLCV-infected plants (Csizinszky *et al.,* 1996, 1999). In addition to reducing incidences of whitefly-transmitted viruses such as TYLCV, reflective mulches can also reduce incidences of aphid- and thrips-transmitted viruses.

2.4.3. Physical barriers

2.3.3. a. Whitefly-proof screens

Physical barriers such as fine-mesh screens have been used in the Mediterranean Basin since 1990 to protect crops from TYLCV (Berlinger & Lebiush Mordechi, 1996; Berlinger *et al.,* 2002; Cohen & Antignus, 1994). Net houses covered by50-mesh screens became a necessity due to the spread of TYLCV and its whitefly vector. The 50-mesh whitefly-proof screens decreased dramatically the number of invading whiteflies into covered net or greenhouses combined with a few insecticide sprays. In Sudan fields (Jamal, 2012) showed that the combined effect of the covering the seeding in the nursery and spraying with fungicide in the field resulted in significant increase in the yield. But, the effect of the fungicide application alone gave insignificant increase in yield (ton ha).

. In the control unscreened greenhouse TYLCV incidence reached 100% despite daily insecticide sprays (Berlinger & Lebiush Mordechi, 1996).

Adoption of physical barriers does add to production costs and screens can create problems of shading, overheating, and poor ventilation. The combination of 50-mesh screens and a positive pressure ventilation system may reduce whitely penetration as well as reducing the ventilation problems and overheating. It should be noted that although 50-mesh screens are indeed highly efficient in excluding whiteflies, these screens alone may not sufficiently protect against TYLCV since some whiteflies are still able to enter houses through gaps in entrances and on personnel. Some insecticide application should be combined when using screens.

2.4.3. b. UV absorbing plastics and screens

Good results have been reported in protected production in Israel when ultraviolet absorbing plastic films were used as greenhouse covers or insect-proof nets (Antignus *et al.*, 1998, 2001). UV-absorbing plastics reduce levels of UV light, blinding the whiteflies which use the light UV wavelengths to navigate. These UV-absorbing films have been shown to inhibit penetration of whiteflies in to greenhouses and to reduce movement of whiteflies within greenhouses. Furthermore, filtration of UV light was shown to hinder the dispersal activity of whiteflies, and consequently reduce TYLCV spread (Antignus *et al.,* 2001). It is important to note that besides the higher production cost, the use of these screens, may also result in increased temperature and humidity inside greenhouses.

2.4.4. Use of resistant cultivars

The use of TYLCV-resistant tomato cultivars, when available, is the best approaches to reduce losses due to infection by TYLCV.Resistant commercial cultivars are available in a limited number of genotypes. A 30-year breeding effort by multiple programs has resulted in numerous cultivars with variable levels of resistance using genes derived from wild tomato species (Lapidot & Friedmann, 2002).

Some of these resistances collapse under early or severe infection pressure and require additional cultural and chemical control measures that reduce whitefly populations to protect the plants from infection. The challenge today is a cultivar that combines high levels of resistance with high fruit quality. High quality TYLCV-resistant tomato cultivars suitable for production in the Mediterranean region have become available only recently. In Sudan, growers are still

forced to rely on the use of cultural and chemical approaches.

2.4.5. Production and use of virus-free transplants

The production season should begin with the use of virus-free transplants. This can be accomplished by purchasing or producing tomato transplants in isolated areas away from production fields or houses. The greater the distance between production areas and nurseries, the lower incidence of infected transplants will be an antifeeding insecticide (such as pymetrozine) can be applied to transplants during their production, reducing transmission rates by whiteflies. Each application will give approximately one week of protection. Transplant production houses which are enclosed by 50 mesh or smaller screens can effectively exclude whiteflies and reduce the frequency of TYLCV-infected transplants. These houses must be well sealed and entrances constructed in such a way as to prevent whitefly intrusion. A positive pressure ventilation system used with 50 mesh screening can be even more effective.

The use of a protective dose of a neonicotinoid in the transplant house a week before plants are set in the field will protect plants for the first 2 weeks (open field production). Young tomato plants are very attractive to whiteflies and are highly susceptible to TYLCV. Neonicotinoids have been shown to have a negative impact on pollinators; therefore, they are not always used in protected production. Application of a neonicotinoid insecticide in the setting water at the rate recommended could provide 8 weeks of protection (open field production).

2.4.7. Chemical approaches

Chemical approaches can be effective in reducing economic losses in tomato to TYLCV. A number of different classes of chemicals have been used to reduce whitefly populations including chlorinated hydrocarbons , organophosphates , neonicotinoids, pyridine-azomethines, and pyrethroids. Many of these chemicals are used primarily in field production. For protected production, fewer chemicals in fewer applications are required and desired due to the non target effects of these chemicals on pollinators. In many locations whiteflies have developed resistance to many of these chemicals and efficacies have decreased over time . In addition to these insecticides, oils, insecticidal soaps, and insect growth regulators have been used. The most effective and widely used class of insecticides to reduce whitefly populations is the neonicotinoids of which at least three (thiomethoxam, imidacloprid, and dinotefuron) have been used to reduce incidence of TYLCV-infected tomato plants (*Ahmed et al.,* 2001; Cahill *et al.,* 1996; Polston & Anderson, 1997).In Florida and in Israel neonicotinoids applied as drenches and less often as sprays, is the main line of TYLCV management. Neonicotinoids are used at reduced rate in the plant house on tomato transplants for protection for the first2 weeks in the field, and then are applied at higher rates in the setting water at the time of transplant. The setting water application is applied at a rate that gives approximately 8 weeks of whitefly control. Once whiteflies begin to develop on the tomato plants then a rotation of non-neonicotinoid insecticides such as insect growth regulators, oils and soaps, and several contact insecticides can be employed through final harvest. Resistance to neonicotinoids has been shown in several locations around the world (Schuster & Gilreath, 2003).

In Israel the majority of tomato is produced under nets or in green houses, and bumblebees are used routinely for pollination. It was demonstrated that bumblebee is the most efficient pollinator in greenhouse tomato(Zaks, 1997).

However, the use of bumblebees in a greenhouse requires a different pest protocol approach, preferably a nonchemical approach. Insecticides application should to be monitored carefully so as not to adversely affect the activity of the bumblebees. (Zeidan, 2005) recommended that the use of insecticides be stopped prior to introduction of bees for crop pollination. However, many insecticide suppliers provide specific information regarding their effect on pollinators and on the timing of applications to minimize the effects on pollination.

2.4.8. Biopestcide Use:

Insecticides were becoming deadlier and deadlier. Specialists were concerned only about efficacy and were losing the overall picture used. Synthetic insecticides are widely used in most developing countries to control insect pests of food crops. This has contributed to the environmental pollution through air or as residues in food. In the last years is the use of environmentally Biopestcide, such as plant extracts widely increased such as Neem and Argel or Harjal (*Solenostemma argel* Del. Hayenne) This plant is a member of the family Asclepiadaceae, which comprises numerous medicinal plants. Phyto-chemicals of medicinal properties from argel shoots had been reported by many workers (*Kamel et al.,* 2000; Hamed, 2001). Antimicrobial properties of argel were reported by,*Elhady et al.* (1994). Soil application of argil's dry leaves under the conditions of the Northern State enhanced flowering and yield of a dry date cultivar and the influence was attributed to either pesticide or growth promoting ingredient

CHAPTER THREE

MATERIALS AND METHODS

The present study was conducted into two phases during winter season 2013-2014. First phase comprised of tomato seedlings preparation and which started in Nursery of Horticultural sector (Elmogran), federal Ministry of Agriculture. While the second phase involved tomato seedling transplanting to the field of the faculty of Agricultural Sciences (Shambat), Sudan University of Science and Technology.

3.1 Seed Collection:

Three hybrids F1 varieties, namely, variety Omdurman which was collected from Diseases Plant Researches Center, varieties Namib and VT60788 were collected from Syngenta Agrosericvice, Country Representative Office (CRO)-Sudan (Appendices).

3.2 Nursery Preparation:

Four trays with wetted betmosoil was prepared for seedlings sawing and divided into four treatments, one tray for each. The first and second trays were assigned and covered with mosquito net mesh screen 50 cm to control white-fly, where as the third tray was allotted for uncovered seedlings treated with Actara fungicide. Last tray was for (control) uncovered untreated seedlings.

All Trays were sown with an equal amount of seeds from each of the three varieties. Irrigation was performed regularly. Seedlings in each of the four groups were allowed to grow till the time for transplanting to the field.

3.3 Field Preparation

3.3.1 Seedlings transplanting and experiment lay out

The seedlings were transplanted six weeks after sowing to Shambat field after adaptation period of seven days. Transplanting was done in the afternoon. Individual seedlings of each variety were carefully transplanted from wetted trays to black plastic sacks (60 x 40cm) filled up to two third with loamy soil after being fertilized with NPK (2 gm/seedling), wetted with water and arranged in split plot design with three blocks (replications) . In each block, (four) groups were assigned to main plots, each of 18 sacks, and varieties to sup plots, each of 6 sacks. The transplanted seedlings were irrigated immediately.

3.4 Application of treatments

Group one and two seedlings (covered seedlings plus Argel as foliar or soil application) were treated with Argel as botanical product. In group one Argel was applied as foliar application (10g|l) where in group two Argel was used as soil added application as the powder (5g/sack) at two weeks interval. In group three seedlings (Uncovered plus chemical treated seedlings), the insecticide Folimat (2ml/L) was applied on weekly basis to control whitefly (*Bemisia tabaci*), other pesticide for other insect and fungicide. Whereas group four as uncovered and untreated seedlings (control).

3.5 Data collection

Three plants were labeled randomly from each variety (subplot) for recording the incidence of tomato leaf curl symptoms and severity in each of the three blocks.

3.5.1Observation of disease symptoms:

The slices symptoms observe weekly.

3.5.2 Disease incidence of TLCV:

Recording of data started at week five from transplanting and continued to week nine tell fruit setting. At each visit, labeled plants from covered (group one and two), uncovered treated with chemicals and uncovered untreated (control) seedlings were inspected for TYLC symptoms. Plants showing disease symptoms were recorded. The disease incidence was expressed as percentage (%) of infected plants from total number of plants inspected as follows: -

$$\frac{No.of\ disease\ plants}{total\ No.of\ plants} \times \mathbf{100}$$

3.5.3 Disease Severity Rating:

Symptoms development was evaluated according to the following scale as described by (Horsfall and Barrat, 1945).

Disease severity= $\frac{sum\ scal \times NO.of\ plant\ infected}{highest\ scal \times total\ NO\ of\ plant.}$

- 0 = No visible disease symptoms (0%);
- 1 = very slight yellowing of leaflet margins on apical leaf (1-25%);

- 2 = some yellowing and minor curling of leaflet ends (26-50);
- 3 = a wide range of leaf yellowing, curling and cupping, with some reduction in size, yet plants continue to develop (51-75%) and
- 4 = very severe plant stunting and yellowing, pronounced leaf cupping and curling; plants stop growth (76-100%).

3.6 Statistical Analysis

The collected data were subjected to standard statistical analysis. The procedure of analysis of variance (ANOVA) and mean separation were followed according to the description of Gomez and Gomez (1984). The data was analyzed by MSTAT-C Statistical Package.

CHAPTER FOUR

RESULTS

4.1. The effect of covering seedling with mosquito net on the plant growth.

Generally the results revealed that covering of the tomato seedlings with mosquito net at nursery for six weeks before transplanting to the field improved the germination of seeds and vigor of the seedlings (plates 1,2 and 3).

The results of the effect of covering seedlings practice plus (Argel as foliar spray and soil application) and chemical spray treatments on incidence of TYLCV disease after five weeks from transplanting are presented in:

4.2. The effect of covering and argel foliar and tomato variety on the incidence of the TYLCV disease.

Table (1). The results indicated that there was significant differences among treatment and varieties Covered + Argel foliar with(VT60788)Varity (0%), and with (Namib)Varity (11.1%).The lowest incidence value (0%) was obtained by the interaction Covered + Argel foliar treatment with(VT60788)Varity. Among treatments, the covered seedlings plus foliar spry reduced the incidence of the disease to 14.8 % compared with control that gave 44.4% incidence.

4.3. The effect of covering and argel soil application and tomato variety on the incidence of the TYLCV disease.

Table (1) . The results indicated that there was significant differences among treatment and varieties Covered + Argel soil with(VT60788)Varity (11,1) Covered + Argel soil treatment with(Namib)Varity (0%))it is the lowest incidence value whereas the highest incidence (44.4%) was recorded in the control. Likewise, among treatments, the covered seedlings plus soil application with Argel reduced the incidence of the disease to 11.1% compared with control that gave 44.4% incidence.

At week six the lowest disease incidence (33.3%) was demonstrated by (Covered + Argel soil application). The percentage disease incidence at week six, seven and eight was shown in Tables (2, 3, and 4). During this period of time the Covered + Argel soil treatment with(Namib)Varity exhibited significantly low incidence of disease (22.2%). This interaction continued to maintain the significantly low disease incidence up to the weeks six and seven.

4.4. The effect of covering and chemical (Folimat) application and tomato variety on the incidence of the TYLCV disease.

Table (1). The results indicated that there was a significant difference among treatments and varieties**,** chemical treatment with (VT60788) variety (11.1%)**.**

Among varieties although the difference is not significant but V1 (VT60788) and V3 ((Namib) performed better than V2 (Omdurman). The lowest incidence (16.7%) was obtained by V1 (VT60788) fallowed by V3 ((Namib) (17.9%) and the highest incidence (30.5%) occurred in V2 (Omdurman).

At week eight the variations in disease incidence among treatments, varieties and interactions were very minor due to high level of disease incidence in all treatments.

Table,1: Effect of covering ,chemical spray (foilmat) , argel and tomato , varieties on incidence (%)of TYLCV at 5th week

Any two mean value (s) bearing different superscripts (s) are differing significantly (p<0-0.5).

Data in parentheses transformed using square root transformation$\sqrt{X + 0.5}$*) before analysis*

Treatments	V1 (VT60788)	V2 (Omdurman)	V3 (Namib)	Means
Covered + Argel foliar	0(0.70)c	33.3(5.8) a b	11.1(2.4) b c	14.8(2.96) a
Covered + Argel soil	11.1(2.4) b c	22.2(4.1) a b	0(0.7) c	11.1(2.40) a
Chemical spray(folimat)	11.1(2.4) b c	22.2(4.1) a b	22.2(4.1) a b c	17.9(3.53) a
Control	44.4(6.6) a	44.4(6.6) a	44.4(6.6)a	44.4(6.60) a
Means	16.7(3.0) a	30.5(5.5) a	17.9(3.45) a	
CV%				52.21
LSd v				3.51
LSd t				4.73
LSd v*t				3.51

Table, 2: Effect of covering, chemical spray(foliar),argel and tomato varieties on incidence(%) of TYLCV at 6th week .

Any two mean value (s) bearing different superscripts (s) are differing significantly (p<0-0.5).
Data in parentheses transformed using square root transformation$\sqrt{X + 0.5}$*) before analysis.*

Treatments	V1 (VT60788)	V2 (Omdurman)	V3 (Namib)	Means
Covered + Argel foliar	66.7(8.0) a	66.7(8.0) a	55.5(7.2) a b	63 (7.73)a
Covered + Argel soil	33.3(5.5) a b	44.4(6.6) a b	22.2(4.1) b	33.3(5.50) a
Chemical spray (folimat)	55.5(7.2) a b	55.6(7.4) a b	44.4(6.6) a b	51.8(7.06) a
Control	66.7(8.0) a	66.7(8.0) a	66.7(8.0) a	66.7(8.00)a
Means	55.6(7.25) a	58.4(7.50) a	47.2(6.48) a	
CV%				27.47
LSd v				3.37
LSd t				3.99
LSd v*t				3.37

Table, 3: Effect of covering, chemical spray(folimat) and tomato varieties on incidence(%) of TYLCV at 7th week .

Any two mean value (s) bearing different superscripts (s) are differing significantly (p<0-0.5).
Data in parentheses transformed using square root transformation $\sqrt{X + 0.5}$*) before analysis*

Treatments	V1 (VT60788)	V2 (Omdurman)	V3 (Namib)	Means
Covered + Argel foliar	66.7(8.0) a	66.7(8.0) a	55.5(7.2) a b	63 (7.73)a
Covered + Argel soil	33.3(5.5) a b	44.4(6.6) a b	22.2(4.1) b	33.3(5.50) a
Chemical spray (folimat)	55.5(7.2) a b	55.6(7.4) a b	44.4(6.6) a b	51.8(7.06) a
Control	66.7(8.0) a	66.7(8.0) a	66.7(8.0) a	66.7(8.00)a
Means	55.6(7.25) a	58.4(7.50) a	47.2(6.48) a	
CV%				27.47
LSd v				3.37
LSd t				3.99
LSd v*t				3.37

Table, 4: Effect of covering, chemical spray(folimat),argel and tomato varieties on incidence(%) of TYLCV at 8th week .

Any two mean value (s) bearing different superscripts (s) are differing significantly (p<0-0.5).
Data in parentheses transformed using square root transformation $\sqrt{X + 0.5}$*) before analysis*

Treatments	V1 (VT60788)	V2 (Omdurman)	V3 (Namib)	Means
Covered + Argel foliar	83.4(9.1) a	55.6(7.4) a	55.6(7.4) a	64.9(7.97) a
Covered +Argel soil	77.7(8.8) a	66.7(8.0) a	88.9(9.4) a	77.8(8.73) a
Chemical spray(folimat)	77.7(8.8) a	88.9(9.4) a	66.7(8.0) a	77.8(8.67) a
Control	88.9(9.4) a	100(10) a	100(10) a	96.3(9.80) a
Means	81.9(8.98) a	77.8(8.70)a	77.8(8.70) a	
CV%				18.08
LSd v				2.74
LSd t				1.79
LSd v*t				2.74

The effect of covered seedlings plus (Argel as foliar spray and soil application) and chemical spray treatments on severity of TYLCV disease after five weeks from transplanting are presented in tables (5, 6, 7 and 8).

4.5. Effect of covering and argel foliar and tomato varieties on the disease severity of (TYLCV).

At week five the severity of TYLCV was very low in a treatment and no significant differences in between. Lowest value (0%) Namib and VT60788 varieties, highest value (8.3%) on Omdurman Varity.

4.6. Effect of covering and argel soil application and tomato varieties on the disease severity of (TYLCV).

At week five the severity of TYLCV was very low in a treatment (0%) and no significant differences in between, it showed the lowest disease severity (0%)with all varieties. In week six the interaction Covered + Argel soil application treatment with (VT60788)Varity continued to give the significantly lowest severity of disease (0%). Moreover, among interactions that of Covered + Argel soil application treatment with a three varieties gave the lowest severity values compared to control.

4.7. Effect of chemical spray (folimat) and tomato varieties on the disease severity of (TYLCV).

At week five the severity of TYLCV was very low in a treatment and no significant differences in between. it showed the lowest disease severity (0%) with all varieties. In week six the chemical treatment with (VT60788) Varity continued to give the significantly lowest severity of disease (0%). Moreover, among interactions of chemical treatment with a three varieties gave the lowest severity values compared to control. The data in table seven indicated that the significantly lowest severity value (8.3%) was given by chemical treatment with (VT60788) Varity. Among varieties there were no significant differences in severity values.

There were no significant differences between other treatments and varieties. In week eight, the tomato plants from all varieties and under all treatments and interactions were severely affected by TYLCV disease. The lowest severity value was (58.3%) and the highest was (91.7%).

4.8. Symptoms of tomato yellow leaf curl virus disease.

The symptoms of diseases observed on plates 4, 5, 6 and7.

Table, 5: Effect of covering, chemical spray and tomato varieties and their interaction on severity of TYLCV at week

Any two mean value (s) bearing different superscripts (s) are differing significantly (p<0-0.5).
Data in parentheses transformed using square root transformation$\sqrt{X + 0.5}$*) before analysis*

Treatments	V1 (VT60788)	V2 (Omdurman)	V3 (Namib)	Means
Covered + Argel foliar	0(0.7) a	8.3(2.17) a	0(0.7) a	2.7(1.19) a
Covered +Argel soil	0(0.7) a	0.0(0.7) a	0(0.7) a	0(0.7) a
Chemical spray	0(0.7) a	0.0(0.7) a	0(0.7) a	0(0.7) a
Control	0(0.7) a	8.3(2.17) a	8.3(2.17) a	5.5(1.68) a
Means	0(0.7) a	4.2(1.43) a	2.1(1.07) a	
CV%				37.93
LSd v				2.84
LSd t				1.98
LSd v*t				2.84

Table, 6: Effect of covering, chemical spray and tomato varieties and their interactions on severity of TYLCV at week six

Any two mean value (s) bearing different superscripts (s) are differing significantly (p<0-0.5).
Data in parentheses transformed using square root transformation $\sqrt{X + 0.5}$*) before analysis*

Treatments	V1 (VT60788)	V2 (Omdurman)	V3 (Namib)	Means
(Covered + Argel foliar)	8.3(2.17) a b	25(5.10) a	8.3(2.17) a b	13.9(3.14) a
(Covered +Argel soil)	0.0(0.70) b	16.7(3.63) a b	8.3(2.17) a b	8.3(2.17) a
Chemical spray(folimat)	0.0(0.70) b	16.7(3.63) a b	16.7(3.6) a b	11.1(2.66) a
Control	25.0(5.10) a	25.0(5.10) a	25.0(5.10) a	25.0(5.10)a
Means	08.3(2.17) a	20.9(4.37) a	14.6(3.27) a	
CV%				57.23
LSd v				3.24
LSd t				3.09
LSd v*t				3.24

Table, 7: Effect of covering, chemical spray and tomato varieties and their interaction on severity of TYLCV at week seven

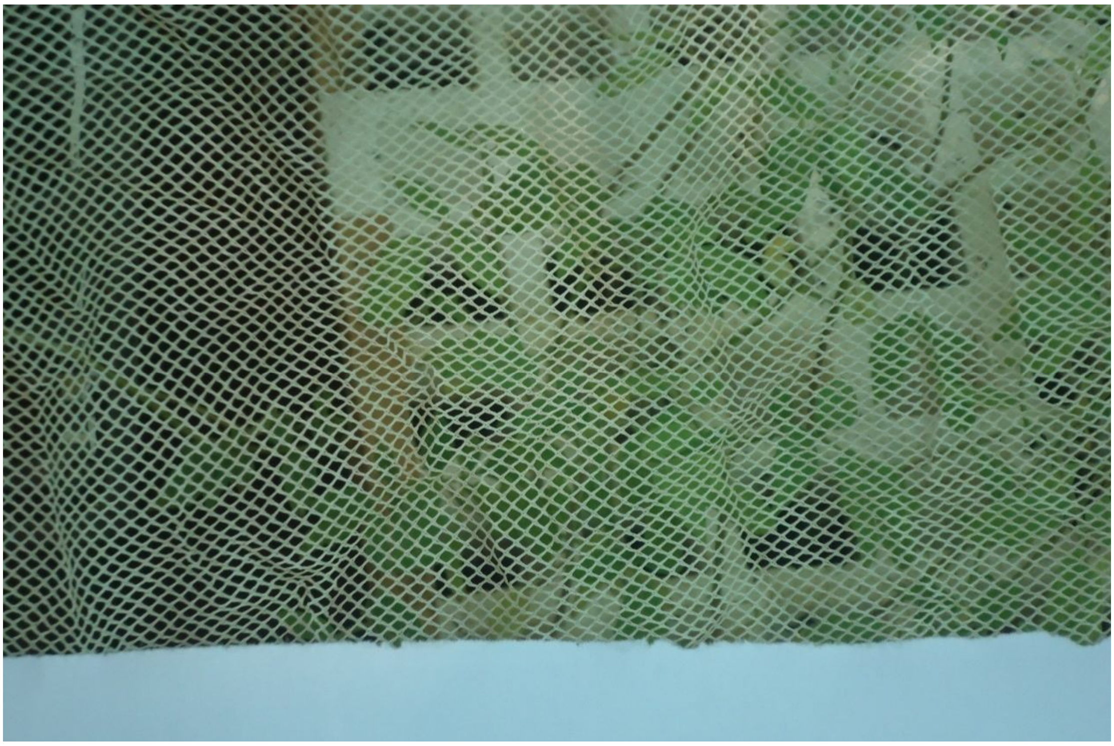
Any two mean value (s) bearing different superscripts (s) are differing significantly (p<0-0.5).
Data in parentheses transformed using square root transformation$\sqrt{X + 0.5}$*) before analysis*

Treatment	V1 (VT60788)	V2 (Omdurman)	V3 (Namib)	means
Covered + Argel foliar	58.3(7.50) a	16.7(3.63) bc	50(7.10) a	50(6.97) a
Covered +Argel soil	41.7(6.43) ab	16.7(3.63) bc	41.7(6.43) ab	33.3(5.50) a
Chemical spray	8.3(2.17) c	41.7(6.43) ab	41.7(6.43) ab	22.2(4.08) a
Control	66.7(8.17) a	29.2(5.00) a	41.7(6.43) ab	50(7.01) a
Means	43.8(6.07) a		43.8(6.60) a	
CV%				26.61
LSd v				2.74
LSd t				3.72
LSdv*t				2.74

Table, 8: Effect of covering, chemical spray and tomato varieties and their interaction on severity of TYLCV at week eight

Any two mean value (s) bearing different superscripts (s) are differing significantly (p<0-0.5).
Data in parentheses transformed using square root transformation $\sqrt{X + 0.5}$*) before analysis*

Treatment	V1 (VT60788)	V2 (Omdurman)	V3 (Namib)	Means
(Covered + Argel foliar)	75(8.7) a b c	91.7(9.57) a	66.7(8.17) b c	77.8(8.81) a
(Covered +Argel soil)	83.3(9.13) a b	91.7(9.57) a	58.3(7.63) c	77.8(8.78) a
Chemical spray	83.3(9.13) a b	83.3(9.13) a b	75(8.7) a b c	80.5(8.99) a
Control	83.3(9.13) a b	91.7(9.57) a	91.7(9.57) a	88.9(9.42)a
Means	81.2(9.03) a	89.6(9.46) a	72.9(8.52)a	
CV%				7.34
LSdv				1.10
LSd t				1.58
LSd v*t				1.10



1: Seedlings covered with Mosquito net

Plate, 2: Seedlings covered with Mosquito net

Plate 3: Uncovered seedlings

Plate 4: experiment lay out

Plate 5: Very slight yellowing of leaflet margins on apical leaf

Plate 6: yellowing**,** curling of tomato leaflet.

Plate 7: Wide range of leaf curling and cupping, with some reduction in size.

CHAPTER FIVE

DISCUSSION

Tomato is considered as one of the most important vegetable crop grown worldwide mainly to be used either fresh or cooked mixed with other vegetables. The crop suffers important losses from infection by yellow leaf curl virus disease which considered a major problem affecting tomato production in many of the old world, tropical and subtropical countries (Abu Jawdah & Shebaro, 1993). The aim of this study was to evaluate the effect of an integrated management approach for control of leaf curl virus disease of tomato that involve the practice of covering tomato seedlings with mosquito net in the nursery, use of resistant varieties, applications of higher plant compound and frequently spraying of synthetic insecticides in order to formulate promising one.

Plates (1 and 2) revealed that covering of the tomato seedlings with mosquito net at nursery for six weeks before transplanting to the field improved the germination of seeds and vigor of the seedlings. This improved establishment of seedlings conferred by the covering may be attributed mainly to intrinsic factor which is the covering of tomato seedlings and consequently complete exclusion of the seedlings from feeding vector that transmits TYLCV and other insect pests and diseases. This is beside the well prepared seed bed and also could be the growing conditions created by covering are more favorable for growing of tomato. This finding is in line with Jamal (2012) who reported that covering of tomato seedlings with mosquito net resulted in vigorous and healthy plants with high plant density.

The data (Table, 1 and 5) revealed that use of integrated management approaches as use of covered seedlings with mosquito net for six weeks in the nursery, tolerant cultivars, spray of synthetic chemical and botanical products reduce the incidence and severity of tomato yellow leaf curl virus disease. The potency conferred by these integrated approaches could be attributed to a multitude of factors. The practice of covering seedlings with mosquito net for six weeks in the nursery prior to transplanting may be resulted in TYLCV free plants that vigorous and healthy enough to tolerate field infection by the disease compared to uncovered. This is in addition to the different types of chemicals that work on controlling the vector population. These justifications were supported by the finding of Cohen and Antigenus (1994) who reported that exclusion of

insect pests and diseases by growing tomato seedlings in an insect proof green house resulted in significant decrease in TYLCV disease incidence. Similarly, Nakhla & Maxwell (1998) reported that several method have been developed to control TYLCV disease such as the use of healthy transplants, chemical and physical control of the vector, crop rotation, and breeding for resistance to the disease. Also Ahmed, *et al.*, (2008) reported that covering the seedlings in the nursery increased the percentage of seed germination and seedling vigor compared with uncovered seedlings.

The data (Table, 1, 2, 3, 5. 6 and 7) showed that the combined effect of Argel applications, synthetic chemicals and varieties reduced the incidence and severity of TYLCV disease compared to control. Similarly, the Phyto-chemicals and repellent properties from Argil had been reported by many workers (Elhady *et al.* (1994); Kamel *et al.*, 2000; Hamed, 2001).soil application of Argil's dry leaves under the conditions of the Northern State enhanced flowering and yield of a dry date cultivar and the influence was attributed to either pesticide or growth promoting ingredients. Moreover, the most effective and widely used method of control to reduce whitefly populations and consequently incidence and severity of TYLCV
is insecticides (Cahill *et al.*, 1996; Polston & Anderson, 1997 and Ahmed *et al.*, 2001).

Late weeks of the experiment demonstrated remarkable increase in TYLCV incidence and severity (Table, 4 and 8). This could be attributed to the high populations of white fly's vector that acquired the virus in Shambat area as well as the availability of adjacent alternative hosts for the insect vector. These results are in line with Geneif (1986) and Jamal (2012) who reported that the rate of TYLCV disease was high in Shambat area than other locations.

Conclusion:

- Generally, the results revealed that covering of the tomato seedlings with mosquito net at nursery for six weeks prior to transplanting to the field improved the germination, health and vigor of the seedlings.
- Covering the tomato seedlings with mosquito net at nursery for six weeks prior to transplanting to the field excludes insect pests and disease in the close vicinity.
- The combined effect of different chemicals, varieties and covering of seedlings resulted in significant decrease of TYLC disease incidence and severity
- Integration of different disease management approaches as used in this study proved to be more effective in reducing TYLCV disease incidence and severity rather than use of one single approach.

Recommendations:

i. The practice of covering tomato seedlings with mosquito net in nursery proved to be effective in protecting the plants form infection by TYLV disease for considerable period of time during the season. This necessitates more studies to determine the optimum time for seedlings to stay under covering prior transplanting.

ii. Further investigation on Argel as repellent and as antimicrobial will help in this direction.

iii. The research on integrated disease management should include more intrinsic factors like cultural practices

CHAPTER SIX

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APPENDICES

Appendix Table 1: ANOVA table of TYLCV disease incidence at week 5

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	Value	Prob
2	Factor A	3	94.887	31.629	5.0526	0.0298
-3	Error	8	50.080	6.260		
4	Factor B	2	30.345	15.173	3.7074	0.0475
6	AB	6	33.235	5.539	1.3535	0.2914
-7	Error	16	65.480	4.093		
	Total	35	274.028			

Appendix Table 2: ANOVA table of TYLCV disease incidence at week 6

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
2	Factor A	3	33.927	11.309	2.4896	0.1345
-3	Error	8	36.340	4.542		
4	Factor B	2	6.855	3.427	0.9073	
6	AB	6	5.245	0.874	0.2314	
-7	Error	16	60.440	3.777		
	Total	35	142.807			

Appendix Table 3: ANOVA table of TYLCV disease incidence at week 7

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
2	Factor A	3	7.208	2.403	1.0810	0.4106
-3	Error	8	17.780	2.222		
4	Factor B	2	4.535	2.267	0.9774	
6	AB	6	15.045	2.507	1.0808	0.4143
-7	Error	16	37.120	2.320		
	Total	35	81.687			

Appendix Table 4: ANOVA table of TYLCV disease incidence at week 8

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
2	Factor A	3	15.447	5.149	5.8680	0.0203
-3	Error	8	7.020	0.877		
4	Factor B	2	0.605	0.303	0.1197	
6	AB	6	11.815	1.969	0.7791	
-7	Error	16	40.440	2.527		
	Total	35	75.327			

Appendix Table 5: ANOVA table of TYLCV disease severity at week 5

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
2	Factor A	3	8.604	2.868	2.6667	0.1189
-3	Error	8	8.604	1.076		
4	Factor B	2	1.076	0.538	0.2000	
6	AB	6	7.529	1.255	0.4667	
-7	Error	16	43.022	2.689		
	Total	35	68.836			

Appendix Table 6: ANOVA table of TYLCV disease severity at week 6

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
2	Factor A	3	44.636	14.879	5.5333	0.0237
-3	Error	8	21.511	2.689		
4	Factor B	2	29.040	14.520	4.1538	0.0352
6	AB	6	18.284	3.047	0.8718	
-7	Error	16	55.929	3.496		
	Total	35	169.400			

Appendix Table 7: ANOVA table of TYLCV disease severity at week 7

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
2	Factor A	3	52.671	17.557	4.4237	0.0411
-3	Error	8	31.751	3.969		
4	Factor B	2	15.929	7.964	3.2434	0.0657
6	AB	6	36.196	6.033	2.4567	0.0706
-7	Error	16	39.289	2.456		
	Total	35	175.836			

Appendix Table 8: ANOVA table of TYLCV disease severity at week 8

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
2	Factor A	3	2.371	0.790	1.1618	0.3825
-3	Error	8	5.442	0.680		
4	Factor B	2	5.332	2.666	6.1069	0.0107
6	AB	6	4.591	0.765	1.7527	0.1728
-7	Error	16	6.984	0.437		
	Total	35	24.720			

Plates 8 (a.b) : Syngenta Agroservice variaties.
Exeperment Fruite(Namib, VT60788)