Agricultural and Biological Sciences Journal
Vol. 1, No. 4, 2015, pp. 150-156
http://www.aiscience.org/journal/absj

Mites (Acarina) as Vectors of Plant Pathogens and Relation of These Pests to Plant Diseases

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Abstract

Almost all plants are under attack by several types of enemies like herbivorous arthropods and plant pathogens. The purpose of this manuscript is to present a comprehensive outline of the pathogens that cause diseases of the various plants and are transmitted by mites. Mites are arachnids related to ticks and spiders, however, differ from insects, and are capable of infesting many orchards, trees, shrubs and plants. Numerous sorts of mites may cause injury to vegetation, but the maximum common are spider mites and adults of two-spotted spider mite (*Tetranychus urticae* Koch Family: Tetranychidae), which are yellowish-green in color by having two conspicuous dark spots on the body, that is a parenchym feeder, and most vegetable crops are its hosts. Mite's damage initially seems as a sufficient speckling or whitening on the upper surface of leaves by reason of pest's nourishing on the underneath and seriously infested leaves turn into bronzed and dry. These versatile tiny creatures not only reduce plant's vigor, but can also transmit some dangerous pathogens causing numerous diseases. The plant pathogens (viruses, fungi and bacteria) are transmitted or spread by mites and belong to different families such as Siteroptidae, Acaridae, Tenuipalpidae, Tetranychidae, Tarsonemidae and Eriophyidae. Repeated control of vector is almost and always necessary to prevent spread of disease; therefore, management tactics must take into consideration the rapid growth period of this pest, particularly throughout hot climate when eggs are laid constantly. Just pursuing on the adults of mite can do a slight worthy if eggs and larvae survive. Dust on leaves, branches and fruit encourages mites, and mid-season washing to remove dust from plants is a worthwhile preventative measure. Water stress makes both trees and plants more susceptible to mite infestations and plants watered properly are helpful to control and prevent further infestations. The use of some of the natural enemies such as lacewing larvae, ladybird beetles, minute pirate bugs, certain thrips species and predatory mites that feed on harmful mites is beneficial for their part as biological control mediators.

Keywords

Two-Spotted Spider Mite, Plant Disease, Pathogens, Damage, Vector

Received: April 10, 2015 / Accepted: May 2, 2015 / Published online: June 3, 2015

1. Introduction

Mites include in the group Acari, which is the prime assemblage inside the arthropods of Class Arachnida, with many thousands described species throughout the world. In distinction to additional arachnid groups such as spiders and scorpions, mites are distinguishing in both their minor size (adult body length going from 0.1-30 millimetres) and ecological multiplicity. Mites are among the oldest known groups of arthropods, some are predators, many mites feed on plants, fungi and microorganisms, and act as parasites in or on the bodies of other animals. Several mite species are severe pests of agricultural crops, either by direct destruction or indirectly as vectors of plant pathogens. There are many types of mites and these tiny black or red specks creatures have several preferred plant hosts. Mites may be found on landscape, ornamental or houseplants and as sucking arthropods can do a lot of damage to the health of trees,

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vegetables, fruits and even some herbs. These versatile minute individuals feed on plants by piercing plant cells and feeding on the moisture inside. This activity leaves necrotic or yellowing spots on the infested hosts. Speckling on foliage is a classic sign of mite's activity. Many species of mite reduce plant vigor but can also transmit some dangerous viruses, fungi, bacteria and diseases. Such an organism that spreads pathogens is plants is called vector. A pathogen is an organism that causes disease in the host plants. Several ecological situations may be essential for disease to transmit and develop (Carey and Bradley, 1982; Sarwar, 2004; 2014 a). For these reasons, this article provides comprehensive information about the identification, biology, damage and management of mites.

2. Appearance and Life History of Mites

There are thousands of species of mites and spider mites are small arthropods, which can be red, green brown or cream in color. They live in associations, typically on the lower side of leaves. Spider mites can replicate speedily in hot and dry climate. After mating, females continuously produce as many as 300 eggs completed in a twosome of weeks. Adult females pledge tiny, red to cream color eggs over a leaf, bark or in webbing. Immature mites look like adults, excluding these have simply six legs for the duration of the first instar stage. Through advantageous temperature and acceptable nutrition, a generation can be accomplished in 7 to 10 days. Mites can catch wind currents and scatter to other plants when the foliage eminence deteriorates on seriously infested plants. Mites can overwinter in more than a few stages of development, like as eggs deposited near dormant buds and as adult females under rough bark scales or ground litter (Herbert, 1982; Sarwar, 2014 b).

The two-spotted spider mite (*Tetranychus urticae* Koch Family: Tetranychidae), is one of many phytophagous or plant feeding species, which very thoroughly correlates to spiders than to insects. Under optimal situations of high temperature and low humidity, this mite can complete its growth in 5 to 7 days. Under additional usual temperature and humidity, the generation interval is around 19 days. The two spotted mites are precisely tiny arthropods and have an inadequate life cycle. There is no resting stage or pupa in its life cycle and in middle of the summer this cycle can be as short as 7 days. Normally, in the greenhouse the life cycle is about from 7 to 12 days in summer and 12-21 days in winter depending on temperature. The two-spotted spider mite desires hot and dry weather, particularly between 25 and 30^{o}C with low humidity. Fascinatingly, high humidity can really decrease mite numbers. The mite populations mostly contain males and females with females prevailing. Each female produces 15-20 eggs per day with a total of making around 100 eggs. The adult female is 0.6 mm long, round in shape and pale yellow to greenish in color with two distinguishing shady green to black spots on both side of the body. The male is lesser in size, trimmer and has a more diamond shape body (Holmes and Tsai, 1980; Teresia and Oscar, 2013). The two-spotted spider mite has four life stages; egg, larva, nymph and adult. The following information provides an overview of life stages of this pest:-

Egg - The sphere-shaped, glossy, straw color eggs are very minute. Webbing formed by the mite that supports to clasp the eggs to the leaf surface, makes the eggs hard to see. Afterwards an incubation period of 3 (75°F or 24°C) to 19 (50°F or 10°C) days the eggs hatch. The eggs are generally laid on the underneath of the leaf under a thin layer of webbing; they are minor and shining becoming whitish as they develop.

Larva - The six-legged, colorless, larva looks like the body form of the nymph and adult. It is somewhat bigger than an egg of a mite. Throughout the larval stage, very slight quantity of food is consumed by pest.

Nymph - The eight-legged nymph looks like an adult, but is smaller and not sexually mature. Nymphs go through two stages earlier to become an adult i.e., the proto-nymph and deuto-nymph.

Adult - Adult mites have eight legs, the female is approximately 0.4 mm long and the male is only around 0.3 mm long. Their color varies from pale yellow through green to orange to brown. When observed from overhead, there seem to have 2 dorsal pigmented spots, which are essentially contents of the gut displaying through the body wall. A female can lay from 50 to 100 eggs throughout its lifetime. Unfertilized eggs grow into males, and fertilized eggs into females. The sex ratio can vary noticeably, but typically favors the females.

3. Mites as Vectors of Plant Pathogens

The transmission of plant pathogens by arthropods demonstrates the complication and diversity of associations between plant pathogens and the arthropods that route and familiarize these to the plants. Since plants and plant pathogens cannot travel by themselves, plant pathogens generally need moveable vectors. Arthropods are thought to be imperative in the spread of the several plant pathogens. Most important plant pathogen vectors are mites, insects or nematodes. The plant pathogens (viruses, fungi and bacteria) are transmitted or spread by mites belonging to different

families such as Siteroptidae, Acaridae, Tenuipalpidae, Tetranychidae, Tarsonemidae and Eriophyidae. For each pathogen there are briefly reported the mites testified as vector or carrier, the main symptoms of the disease and the proposals of control (Blake, 1988). In the course of a study on the variety of mites of agricultural significance, a record of pathogens infecting plant and edaphic mites is made. Numerous species of Eriophyoidea are found to be infected by *Hirsutella* sp. Resting spores of Entomophthorales are detected in mites of the families Ascidae, Phytoseiidae, Stigmaeidae, Tetranychidae and Tydeidae. A *Cladosporium* sp., infection has been noted in the eriophyid *Retracus johnstoni* Keifer that is a pest of the palm tree *Syagrus romanzoffiana* (Cham.) Glassman. The fungus has been sequestered from host and cultivated in synthetic medium (Geest et al., 2002). The fungi are the utmost diverse, common and vital plant pathogens, but the excessive bulk of fungal pathogens require or do not need moveable vectors such as mites. The phoretic female mite *Imparipes haeseleri* (Ebermann & Manfred) has been found on wood-dwelling sphecids (Digger wasps), but also on wood-dwelling wild bees and a eumeninae wasp; and *Imparipes apicola* (Banks) has been primarily found on soil-dwelling bees and some sphecids. Both these mite species use their atrium genital as a transport container (sporotheca) for fungal spores and this kind of sporotheca is unique in the Acari. The manifestation of the two different spore types in the sporothecae is interrelated with the wood-dwelling or soil-dwelling mode of life of the hosts phoresy, and the transported spores belong to at least two fungus species (Van Der et al., 2002; Ebermann and Manfred, 2003; Vacante, 2013).

Some growers become alarmed about the pest when they discovered wart-like growths on leaves of some of their favorite trees and shrubs. All this concern is caused by microscopic arthropods called eriophyid mites or more commonly the gall mites. The damage produced by these mites is expressed in a wide variety of symptoms. Some mites cause distortion of developing buds, while others damage to the leaves or flowers. Leaf effects include edge rolling, curling, rusting, stunting, crinkling or the familiar production of galls. The various galls, which may occur on upper or lower leaf surfaces, are shaped like beads, purses, bladders, fingers or nipples. Other galls are expressed as fuzzy patches called erineums. These may occur either flat on the surface or inside indented pockets. Galls and other leaf distortions are induced by salivary phytotoxins secreted by the feeding mites. Eriophyids are not only important because of the direct damage they cause, but because they are also vectors of plant pathogens. The wheat curl mite, which is an eriophyid, has been incriminated as the vector of two viruses of wheat. Other species are also known to transmit at least 10 other disease-causing plant pathogens. The maple bladder gall mite produces one of the most commonly seen galls found on the leaves of silver maple; this condition has attracted particular attention because of the conspicuous galls and the wide distribution of the host plant in the various states. The eruptions on the upper leaf surface are initially green, later on becoming tinted with pink and red colors (Styer and Nault, 1975; Drake et al., 2005).

A decade before, a new mite-transmitted disease has been designated on wheat (*Triticum aesativum*) and maize (*Zea mays*), which because of its geographical location is referred to as High Plains Disease. To define the etiology, colonies of High Plains Disease pathogen-transmitting eriophyid wheat curl mites (*Aceria tosichella*) on wheat plants for preservation of a constant source of infected material are recognized (Skare et al., 2006). Wheat streak mosaic virus (Family: Potyviridae; Genus: Tritimovirus), is a virus vectored by wheat curl mite (*A. tosichella*), which is the most common virus infecting wheat. The spider mite *T. urticae* is a parenchym cell-content feeder; the species pierces parenchym cells and consumes their contents, producing significant leaf damage (Kant, 2008). The *Aceria mangiferae* (Family Eriophyidae) produces distortion, stunting and bud proliferation of new growth on plants, and the mites may transmit mango malformation disease (Gamliel et al., 2009). Mites *Brevipalpus phoenicis* (Geijkes) are actually a complex of morphologically similar species. Brevipalpus transmitted viruses are New World plant pathogens with one known exception, the Orchid fleck virus that is reported worldwide. Citrus leprosis-like symptoms are reported to occur on citrus plants due to these mites (Rodrigues and Childers, 2013). This publication, therefore, contains information on mites' transmitted pathogens in relation to plant disease and how to control the more important pests.

4. Mites Damage to Plants

Mites forage by penetrating leaf cell walls with their mouthparts and suck out the cell's contents. These cells are left non-functional, therefore the injury is well-thought-out unalterable (no longer contributing to plant growth and development). Nevertheless, this does not mean that plants are incapable to yield fresh leaf development if environments favorable to plant growth are developed. Injury to crops is generally first detected close to field borders or grassy areas inside fields. As the flora in non-crop areas develops, and is trimmed or submitted to dearth situations, then mites scatter to adjacent crops. This typically happens in the track of the prevalent winds; meanwhile much of their movement is the result of ballooning on a silken thread. A yellowing of plants in a steady spreading zone ("V" or "U" pattern) close to field

boundaries or in grassy areas inside a field might specify that two-spotted spider mite is existing and becoming customary inside a field. The yellow discoloration, which when observed more thoroughly exposes a mottling or sand blasted looking, and can ultimately take on a bronze then brown color. If left unrestricted, the plants can rapidly become underdeveloped. These undersized plants can yield minor fruits or pods or deprived of bearing at all with an opportunity of plant expiry (Hunt, 2002; Sarwar, 2012). The occurrence of mite's damage to some of plants is given below:-

1. Going on yearly vegetable crops for instance squashes, melons and watermelons, the damage of leaves can have a noteworthy influence on produce and might lead to sun burning.
2. Proceeding on crops for example sugarcane, or peas and beans where pods are attacked, spider mites may cause direct injury.
3. On ornamentals, mites are mainly of an appealing alarm, but they can kill plants if populations become very great on annual plants. Spider mites are too significant pests of field-grown roses.

5. Mite Control Measures to Prevent Spread of Diseases

The best apparent first stair in controlling diseases caused by mite-borne pathogens might appear to be the exclusion of vectors with insecticides. Even though they are precisely operative in certain circumstances, insecticides generally are not the paramount devices for control of maximum vector-borne pathogens of crops. Mites can be challenging to control with chemicals for instance the usage of broad-spectrum insecticide decreases the numerals and efficiency of advantageous insects, and mite populations have established variable grades of resistance to some pesticides. The utmost active tactic in controlling mites is to cartel manifold approaches. For maximum mite species a range of chemical, biological and cultural control approaches are available.

Several issues are needed to take into deliberation in advance to an active mite control measure is functional. From the time when an inadequate economic threshold evidence is existing, a noble understanding of the mites host plant and climatic situations besides a detailed scouting platform can support significantly when making management assessments. Decrease of crop yield in a straight line is linked to the period and amount of mite's attack, with the most severe injury caused by invasions starting in initial plant growth stages and building this during the whole season. Nevertheless, a substantial invasion at seed set can cause seed abortion or deprived seed filling. If leaf yellowing is obvious and hot dry environments are likely to continue, then spider mites are definitely recognized, and it is suggested that a control decision must be considered. Spot treatments may be effective if infestations are trapped timely and mites have not yet progressed all over the field. Victory of spot treatments can be determined by spraying beyond (i.e., 30.5 to 61 m) the pest-ridden zone, on the other hand not just on the spoiled zone. If sampling results specify that pest's movement has happened in some areas of a field or all over the field, then action on the entire field must be well-thought-out (Sarwar et al., 2009; 2012).

5.1. Biological Control

The healthy populations of useful arthropods are of great agricultural importance and can help to keep numbers of pathogen transmitting and pest mites at low level. There are a number of advantageous predatory mites, for example, Persimilis spider mite is one of the world's greatest frequently cultured natural enemies and it forages on bean spider mite and two-spotted mite. Predator mite, *Neoseiulus cucumeris* forages on broad mites and two-spotted mites, while Montdorensis predates on tomato russet mite and broad mite. A predatory mite, *Anystis wallacei*, is used for natural control and has been recognized at certain locations where it has caused noteworthy mortality of red-legged earth mites. However, its efficiency is inadequate by sluggish spreading frequency. Certain natural enemies that nourish on spider mites are green lacewing larvae, small, black ladybird beetles (ladybug), minute pirate bugs, specific thrips species and predatory mites. These natural enemies frequently exist naturally, however occasionally they do not check mite populations from reaching detrimental levels. For the reason that mite predators are enormously vulnerable to numerous insecticides (particularly conventional pesticides), there is no prerequisite to use pesticides until the healthiness or look of the plant is endangered by the mites. If pesticide treatments are essential, constantly restrict the applications to merely those plants that are most extremely pest-ridden, this can aid to marmalade the natural control agent. Some natural enemies for instance predatory mite *N. cucumeris*, can be procured from marketable set-ups to discharge nearby the orchards and lawns (Sarwar, 2009; Sarwar and Saqib, 2010; Sarwar et al., 2011 a; Sarwar et al., 2011 b; Sarwar, 2014 c).

5.2. Cultural Control

Spider mites flare up well on plants under stress, so, it is best practice to retain plants well irrigated and fertilized, because damage is amplified as soon as the plant does not obtain adequate water. In trees, mite eruptions can be prompted by dusty situations alongside unpaved roads for the reason that

these circumstances unfavorably disturb mite predators, irrigating the plants at steady interims when required, and minimizing dirty passage ways that lie near to infested plants. Mite populations can likewise be condensed by spraying plants powerfully by water, particularly on the underneath of leaves, to breakdown the webs and wash-down the mites to ground. Cultural control methods for mites can be applied as often as necessary and the techniques comprise crop rotation, mixed cropping, clean fallowing, weeds control, trap or border crops, changes in tillage practices and minimizing dusty surroundings (Sarwar, 2013 a).

5.3. Resistant Varieties

Knowledge of disease resistance level in currently available cultivars or germplasms and sources of resistance with diverse genetic backgrounds to a particular pathogen are very crucial in the development of resistant cultivars and other disease management strategies. While development of resistant varieties form the first line of defense among the preventative techniques, the breeding of tolerant plant varieties which are commercially suitable has been recognized possible to attain sensible pest control for certain crops. Through choosing varieties with normal resistance to specific mite pests and diseases, the possibility of pest complications occurring and the necessity to control these with feedbacks can be considerably condensed or even escaped. Genetically based plant tolerance to pathogens or resistance to infection without injury of produce delivers the base for the maximum fruitful control programs for vector-borne plant pathogens. Molecular approaches of introducing innovative genes for tolerance or resistance to vector and pathogens directly into crop plants is capable to offer resistance to diseases where no genetic resistance has yet been revealed (Sarwar, 2013 b).

5.4. Chemical Control

Mite complications are frequently encouraged by unnecessary usage of insecticides against other pests that kills the natural enemies of mites and permits their numbers to increase. Mites can be hard to control by chemical resources because of their short life cycles and resistance to chemicals, however miticides can be used if the pest pressure develops in elevation. When natural enemies are not sufficiently adequate to deliver an active spider mite control, conventional miticide applications are occasionally desired to avoid extra plant damage. Underneath are provided some of miticides (both conventional and alternative) which might be effective in controlling mites on trees, plants and shrubs. For the reason that mites can replicate quickly and they can also develop a tolerance to a conventional miticide used frequently, accordingly, it is suggested that the usage of conventional miticides must be interchanged with other types of pesticides, such as oils and soaps. The chemicals enumerated must be, with few exceptions, easily presented to the growers.

For present chemical control choices, some of best common acaricides characterized for control of mites on vegetable and orchard plants are dicofol (Hi-Yield® Kelthane, Bonide® Kelthane), insecticidal soap (Safer® Insecticidal Soap, Concern® Insect Killing Soap), malathion (Ace® Malathion, Ortho® Malathion Insect Spray), pyrethrins (Schultz® House plants and Gardens Insect Spray), rotenone (Hi-Yield® Rotenone, Bonide® Rotenone Insect Control) and sulfur (Hi-Yield® Wettable Sulfur, Bonide® Liquid Sulfur). Some common acaricides branded for control of mites on landscape ornamental plants in addition to above cited products further include superior oil (Sunspray® Ultra-Fine Spray Oil, Ortho® Volck Oil Spray) and permethrin (Spectracide® Permethrin Insect Control). It is important to check the label to make sure that mites and the name of the host plants are listed before any pesticide application is made.

Various substitute chemicals are not systemic in action, thus might seem unsuccessful if normal treatment is not attained. Entirely the foliage must be well covered with the spray, particularly the lower side of the leaf mainly if the chemicals work by contact action with no systemic in action. Application must be made prior to the pest damaging numbers develop i.e., before webbing can be visible. Small droplet size is greatly more effective and can make enhanced interaction with the pest. Depending on the chemical used, the frequent application could need to be made. Most of listed chemicals do not destroy the egg stage or have enough residual action to destroy hatching larvae, so, two applications must be used at about 5-7 days separately to kill all stages of mites. If possible effort to spot treat infestations as a substitute of treating the entire field or greenhouse for the time being due to the reason that mites can develop resistance to chemicals very rapidly when the same chemical is used repeatedly. Try to use chemicals which have diverse types of action (i.e., belong to dissimilar chemical class and act contrarily) in alternation to avoid resistance evolving.

5.5. Botanical Extracts or Plant Based Oils

Chemical pesticide usage actually encourages the spread of spider mites by killing the beneficial insects that prey on them. Mites are also known to develop quick resistance to various pesticides. For these reasons, it is important to control mites with effective, natural and organic methods. If the mite's infestation is severe and has been difficult to control using other means or is affecting particularly prized or vulnerable plants, it is better to apply botanical extracts or other plant-based oils to quickly wipe out pest numbers. To

effectively kill mites, the oil must come into direct contact with the pests, so thorough spraying is crucial and it is usually needed to do several applications. Further, the chemical sprays do not destroy mite eggs, thus it is imperative to spray miticides when maximum mites have been appeared. On fruit trees that are deciduous, a spray of dormant oil (superior type) can support to control mite populations by overwhelming any overwintering eggs or adults found on the tree. Conversely, certain spider mite species do not overwinter on woody plants and would not be affected by a dormant oil spray. Manifold applications of an insecticidal oil or horticultural soap, applied after every 7 to 10 days to many ornamental woody plants and tree fruits during the growing season can too deliver good mite control (Sarwar et al., 2013).

6. Conclusion

This paper deals with the numerous mite vector groups associated with transmission of plant pathogens and the interrelationship of pathogens with the plant diseases. Understanding the influence of a pest species on a specific crop is precarious for the accomplishment of a pest managing package. There are certain modest things which may be carried out to escape great mite quantities, escape introducing of infested seedlings or other plant material into the crop, control weeds that harbor the pest, eliminate old plants that may be a cause of mites for new plantings, intensification of humidity to decrease pest breeding, and recognizing of infestations timely as the mites certainly move to the nearby greenhouse or field. There may also be enhanced the numbers of wild advantageous insects in crop naturally by escaping usage of wide range insecticides, providing safe plant species as habitation nearby the crop and preserving greater levels of organic soil carbon. The usage of pathogens free plants is possibly the most prevalent technique of avoiding their dispersion. This is particularly vital for perennial plants for instance fruit trees or plants propagated from vegetative cuttings like potato, sugar cane or strawberry. Heat treatment or antiviral chemical treatments could be used to yield virus-free new plant growth which can be grafted or rooted to produce virus-free plants for nursery propagation. An area-wide collaboration is needed for field cleanliness to control mites and some pathogens of plant diseases.

References

[1] Blake, J. 1988. Mites and Thrips as Bacterial and Fungal Vectors between Plant Tissue Cultures. Acta Horticulturae, 225: 163-166.

[2] Carey, J.R. and Bradley, J.W. 1982. Developmental rates, vital schedules, sex ratios, and life tables for *Tetranychus urticae*, *T. turkestani* and *T. pacificus* (Acarina: Tetranychidae) on cotton. Acarologia, 23: 333-345.

[3] Drake, C.S., Gary, L.H., Frederick, E., Gildow, K.M.H. and Roy, F. 2005. Plant Virus HC-Pro Is a Determinant of Eriophyid Mite Transmission. Journal of Virology, 79 (14): 9054-9061.

[4] Ebermann, E. and Manfred. 2003. First Record of Sporothecae within the Mite Family Scutacaridae (Acari, Tarsonemina). Zool. Anz. , 42: 367-375.

[5] Gamliel, A., Freeman, E.S., Sztejnberg, A., Maymon, M., Ochoa, R., Belausov, E. and Palevsky, E. 2009. Interaction of the mite *Aceria mangiferae* with *Fusarium mangiferae*, the causal agent of mango malformation disease. Phytopathology, 99:152-159.

[6] Geest, L.P.S., Elliot, V.S.L., Breeuwer, J.A.J. and Beerling, E.A.M. 2000. Diseases of mites. Exp. Appl. Acarol., 24: 497-560.

[7] Herbert, H.J. 1982. Biology, life tables, and innate capacity for increase of the two spotted spider mite, *Tetranychus urticae* (Acarina: Tetranychidae). Can. Entomol., 113: 371-378.

[8] Holmes, F.W. and Tsai, J.H. 1980. Vectors of Plant Pathogens. Editors Harris, K. F. and Maramorosch, K. Academic Press London. 467 p.

[9] Hunt, R.S. 2002. Forest losses to pest insects/ mites and plant pathogens. Pages 298-300. In D. Pimentel, editor. Encyclopedia of Pest Management. Marcel Dekker, Inc., New York, Basel. 929 p.

[10] Kant, M.R., Sabelis, M.W., Haring, M.A. and Schuurink, R.C. 2008. Intraspecific variation in a generalist herbivore accounts for differential induction and impact of host plant defences. Proceedings of the Royal Society B, 275: 443-452.

[11] Rodrigues J.C.V. and Childers, C.C. 2013. Brevipalpus mites (Acari: Tenuipalpidae): vectors of invasive, non-systemic cytoplasmic and nuclear viruses in plants. Experimental and Applied Acarology, 59: 165-175.

[12] Sarwar, M. 2004. Stored grain and stored product mites from Pakistan and Azad Kashmir. Pakistan & Gulf Economists, XXIII (10): 30-31.

[13] Sarwar, M. 2009. Populations' synchronization of aphids (Homoptera: Aphididae) and ladybird beetles (Coleoptera: Coccinellidae) and exploitation of food attractants for predator. Biological Diversity and Conservation, 2 (2): 85-89.

[14] Sarwar, M. 2012. Frequency of Insect and Mite Fauna in Chilies *Capsicum annum* L., Onion *Allium cepa* L. and Garlic *Allium sativum* L. Cultivated Areas, and their Integrated Management. International Journal of Agronomy and Plant Production, 3 (5): 173-178.

[15] Sarwar, M. 2013 a. Management of Spider Mite *Tetranychus cinnabarinus* (Boisduval) (Tetranychidae) Infestation in Cotton by Releasing the Predatory Mite *Neoseiulus pseudolongispinosus* (Xin, Liang and Ke) (Phytoseiidae). Biological Control, 65 (1): 37-42.

[16] Sarwar, M. 2013 b. Comparing abundance of predacious and phytophagous mites (Acarina) in conjunction with resistance identification between Bt and non-Bt cotton cultivars. African Entomology, 21 (1): 108-118.

[17] Sarwar, M. 2014 a. Knowing About Identify and Mode of Damage by Insect Pests Attacking Winter Vegetables and Their Management. Journal of Ecology and Environmental Sciences, 2 (4): 1-8.

[18] Sarwar, M. 2014 b. Some Insect Pests (Arthropoda: Insecta) of Summer Vegetables, Their Identification, Occurrence, Damage and Adoption of Management Practices. International Journal of Sustainable Agricultural Research, 1 (4): 108-117.

[19] Sarwar, M. 2014 c. The propensity of different larval stages of lacewing *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) to control aphid *Myzus persicae* (Sulzer) (Homoptera: Aphididae) evaluated on Canola *Brassica napus* L. Songklanakarin Journal of Science and Technology, 36 (2): 143-148.

[20] Sarwar, M. and Saqib, S.M. 2010. Rearing of Predatory Seven Spotted Ladybird Beetle *Coccinella septempunctata* L. (Coccinellidae) on Natural and Artificial Diets under Laboratory Conditions. Pakistan Journal of Zoology, 42 (1): 47-51.

[21] Sarwar, M., Ashfaq, M., Ahmad, A. and Randhawa, M.A.M. 2013. Assessing the Potential of Assorted Plant Powders on Survival of Caloglyphus Grain Mite (Acari: Acaridae) in Wheat Grain. International Journal of Agricultural Science and Bioresource Engineering Research, 2 (1) 1-6.

[22] Sarwar, M., Kongming, W. and Xuenong X. 2009. Evaluation of biological aspects of the predacious mite, *Neoseiulus cucumeris* (Oudemans) (Acari: Phytoseiidae) due to prey changes using some selected Arthropods. International Journal of Acarology, 35 (6): 503-509.

[23] Sarwar, M., Kongming, W., Xuenong, X. and Wang, E. 2011 b. Evaluations of four mite predators (Acari: Phytosiidae) released for suppression of spider mite infesting protected crop of sweet pepper (*Capsicum annuum* L.). African Journal of Agricultural Research, 6 (15): 3509-3514.

[24] Sarwar, M., Xuenong, X. and Kongming, W. 2012. Suitability of webworm *Loxostege sticticalis* L. (Lepidoptera: Crambidae) eggs for consumption by immature and adults of the predatory mite *Neoseiulus pseudolongispinosus* (Xin, Liang and Ke) (Acarina: Phytoseiidae). Spanish Journal of Agricultural Research, 10 (3): 786-793.

[25] Sarwar, M., Xuenong, X., Wang, E. and Kongming, W. 2011 a. The potential of four mite species (Acari: Phytoseiidae) as predators of sucking pests on protected cucumber (*Cucumis sativus* L.) crop. African Journal of Agricultural Research, 6 (1): 73-78.

[26] Skare, J.M., Wijkamp, I., Denham, I., Rezende, J.A., Kitajima, E.W., Park, J.W., Desvoyes, B., Rush, C.M., Michels, G., Scholthof, K.B. and Scholthof, H.B. 2006. A new eriophyid mite-borne membrane-enveloped virus-like complex isolated from plants. Virology, 347 (2): 343-353.

[27] Styer, W.E. and Nault, L.R. 1975. Gall Mites in Ohio. Journal of Arboriculture, 60 (1): 188-191.

[28] Vacante, V. 2013. The Mites as Vectors of Pathogens of Plant. Protezione delle Colture, 2: 2-8.

[29] Teresia, W.N. and Oscar, E.L. 2013. Effect of *Tetranychus urticae* (Acari: Tetranychidae), on Marketable Yields of Field-Grown Strawberries in North-Central Florida. Journal of Economic Entomology, 106 (4): 1757-1766.

[30] Van Der, G.L.P.S., De Navia, M.G.J.D. and Tanzini, M.R. 2002. New Records of Pathogenic Fungi in Mites (Arachnida: Acari) from Brazil. Neotrop. Entomol., 31 (3): 493-495.