# Tetranychus urticae in Northern Africa

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In North Africa, Tetranychus urticae Koch, 1836 represents one of the most destructive generalists among mite herbivores. Unfortunately, it is a source of important annual casualties in crop production. It is a phytophagous mite that can feed on hundreds of host plants and produces significant damage. The control of *Tetranychus urticae* in North Africa has been principally based on acaricide sprays. However, new alternative methods have shown effective results, such as artificial ultraviolet-B, natural enemies, and the introduction of new genetic methods.

Tetranychus urticae propagation environment acaricide management

## 1. *Tetranychus urticae* in North Africa

*Tetranychus urticae* is a problematic pest of several global crops [1][2]. It is a generalist species that can feed on hundreds of host plants and produces significant damage to the field, greenhouse, and horticultural crops, as well as ornamental and fruit-bearing trees [3][4][5][6]. It can produce silk threads to protect itself from predators or to disperse from plant to plant. In Egypt, the generations of *T. urticae* follow one another at a rapid pace (approximately 27 generations per year) [7], *T. urticae* on Hood pear variety; the highest mean number of eggs laid by a female was 143.6 eggs/female with a daily rate of 16.7 eggs/female/day at 30 ° C [8]. In Moroccan conditions, this pest presents an optimal development at temperatures of 30 °C. The female can generate a high number of eggs in a short time; for instance, on clementine, they can lay about 34 eggs in a period of 17 days (the biological cycle takes from 8 to 12 days in optimal condition) [9][10]. The drying up of leaves due to *T. urticae*, can negatively affect the crop's green matter (GM) yield. However, a reduction in potassium, nitrogen, and phosphorus has been detected on *Chrysanthemum* infested by *T. urticae*. Additionally, [11] observed a reduction in amylase activity and proteolytic enzyme, and reduced the total amount of proteins. In Tunisia, the economic importance of this mite has expanded on many crops, principally because of its resistance to acaricides [12]. *Tetranychus urticae* in citrus orchards are mainly active during summer and autumn. The highest population density is recorded in July and August. On lemon, the attack can be observed throughout the year if the winter is mild. The varieties of the clementine groups are the joint susceptible to mite attacks causing significant defoliation. In Algeria, *T. urticae* is listed as one of the most dangerous pests that cause immense damage to vegetable plants [13].

## 2. Levels of Infestation and Severity of Spread

*Tetranychus urticae* is a cosmopolitan pest. It occurs in most parts of the world; in Europe, Asia, Africa, Australasia, Caribbean islands, and North America [14]. Further, this pest is adapted to different climatic conditions. In North Africa, especially in Morocco, *T. urticae* is one of the most recorded pests on various crops, including fruit trees (apple and citrus) and spontaneous plants [15][16]. Similar results were cited in Algeria and Tunisia, which are under the same climatic conditions as Morocco [17]. In Egypt, spider mite was found in fruit trees and ornamental vegetation, causing serious damage, according to the infestation rates on these plants [18][19]. The differences in infestation rates can be attributed to the variation of environmental conditions, planting dates, and age of plantation [20].

*Tetranychus* populations multiply fast in the weeds and orchards surrounding vegetation and migrate to occupy the fruit trees [21]. This spread is not always passive but often takes place under the action of various stimuli counting temperature, wind, rainfall, and farming practices [22][23]. On clementine, a study was conducted in the Gharb region of Morocco, in which the orchards were isolated for three cropping annuals and without practice of acaricide treatments, in order to know the severity of infestation rate by *T. urticae*. The infestation degree of the trees was 10% in mid-April, to increase rapidly to 87% in July. The spread occurs when the climatic conditions and the phenological development of the tree are favorable for the deployment of the mite [15]. *T. urticae* have been studied in Moroccan orchards over a period of ten weeks (from 25 March to 2 June 2002) on herbaceous strata and on two different varieties of apple trees ("Golden" and "Anna"). Adventitious plants such as *Cuscuta epithymum*, *Malva neglecta*, *Sonchus asper, Convolvulus arvensis*, and *Urtica urens* (and, to a lesser extent, *Mentha pulegium, Sonchus oleraceus, Papaver rhoeas,* and *Sinapis arvensis*) appear to be the most favorable host plants to *T. urticae*. Hence, they must be considered as potential sources of infestation for the fruit trees.

## 3. Kind of Hosts

*Tetranychus urticae* represents one of the most destructive generalists among mite herbivores [10]. It is considered a major pest decreasing plant growth and yield on different crops [24]. Among these, in North Africa, it attacks flowering plants and fruit crops, such as apricot, cherry (*Prunus* sp.), apple (*Malus domestica*), *Citrus* sp., strawberry (*Fragaria ananassa*), blackcurrant (*Ribes nigrum*), quince (*Cydonia oblonga*), plums (*Prunus domestica*), pear (*Pyrus communis*), cotton (*Gossypium hirsutum*), clover (*Trifolium* sp.), sunflower (*Helianthus* sp.), grapevine, eggplant (*Solanum melongena*), moringa (*Moringa oleifera*), melons, watermelons (*Citrullus* sp.), baby marrow (*Zucchini* sp.), cucumber (*Cucumis sativus*), green beans (*Phaseolus vulgaris*), carrots (*Daucus carota*), peanut (*Arachis hypogaea*), bindweed (*Convolvulus aryensis*), metel (*Datura metel*), alfalfa (*Medicago sativa*), peppermint (*Mentha piperita*), rosemary (*Rosmarinus oflicinalis*), common vervain (*Verbena oflicinalis*), and (*Rosa* sp.) have been recorded [8][25][26].

## 4. Control Methods

### 4.1. Chemical Control

In the commercial orchards of Northern Africa, the protection against pests is currently assured by preventive and intensive chemical control. Despite benefits such as rapid action in the reduction of pests numbers and their easy use when compared to natural extracts from plants [27], this strategy has many limitations; the examination of the action spectrum of the active components used throughout the world reveals that 46% of acaricides, 72% of insecticides, and 28% of fungicides are globally toxic towards auxiliary arthropods and public health [28]. Additionally, spider mites have developed resistances to more than 80 acaricides in more than 60 countries [12]. Particularly, *Tetranychus urticae* has developed resistances to more than 30 organophosphates and carbamates in 40 countries, this resistance is due to mutations in the mitochondrial cytochrome b protein of this pest [29]. Besides, a non-rational application of benomyl [methyl 1-(butylcarba-moyl) benzimidazole-2-ylcarba-mate] and other pesticides killed all noticeable predators of the pest [30]. Therefore, the absence of control by natural enemies due to their death by pesticides can cause a considerable increase in *T. urticae* populations [31].

### 4.2. Biological Control

Biological control agents such as bacteria, predatory insects, or fungi can be used as alternative approaches for control [32]. Bacterial organisms, such as *Yersinia entomophaga*, *Xenorhabdus* spp. *Pseudomonas entomophila*, *Burkholderia* spp. *Chromobacterium* spp. *Streptomyces* spp. *Saccharopolyspora* spp., and *Bacillus* spp. have all recently gained commercial interest for the production of diverse metabolites that act as effective insecticides [33]. Secondary metabolites of fungi, such as *Aspergillus melleus*, *Emericella nidulans* G. Winter, 1884, *Alternaria terreus*, *Chaetomium globosum*, *Trichoderma viridae*, and *Eurotium eurotiorum* are a promising source of control against various agricultural pests [34].

The most important predators that have significantly managed *T. urticae* and other spider mites are *Amblyseius swirskii* (Athias-Henriot, 1962), *Typhlodromus rhenanoides* (Athias Henriot, 1960), *Phytoseiulus persimilis* (Athias-Henriot, 1957), *Typhlodromus phialatus* (Athias Henriot, 1960), *Neoseiulus cucumeris* (Oudemans, 1930), *Neoseiulus stolidus* (Chaudhri, 1968), *Feltiella acarisuga* (Vallot, 1827), *Scolothrips longicornis* (Priesner, 1926), *Euseius scutalis* (Athias Henriot, 1958), *Euseius stipulates* (Athias Henriot, 1960), and *Stethorus punctillum* (Julius Weise, 1891) [35][36].

#### 4.2.1. Myco-Metabolites

The fungal isolates of *Aspergillus melleus*, *Emericella nidulans*, *Chaetomium globosum*, and *Aspergillus terreus* presented practical control activities against females and eggs of two-spotted spider mite [34]. The effect of culture filtrates of fungal isolates showed mortality rates of 52.4%, 52.4%, 48.4%, and 50.4%, exhibited by *Alternaria terreus*, *A. alternata, Trichoderma viridae*, and *Eurotium eurotiorum*, respectively [37]. Further, the laboratory evaluation showed these secondary metabolites of *A. melleus*; (nodulisporic acid, mellamide; ochratoxin C, 7-oxocurvularin,6-(4′-hydroxy-2′-methyl phenoxy)- (−)-(3R)-mellein and 7-oxocurvularin can be used as biopesticides in the biological control of *T. urticae* [34]. Similarly, the *Azadirachta indica* (neem oil) extract registered that the mortality proportion of adults was 100% at all tested concentrations after 72 h of application [38]. In Spain, *Beauveria bassiana* gave impressive results in the control of *T. urticae*, and therefore is a candidate to be included in integrated pest management programs with triflumuron against *T. urticae* [39].

#### 4.2.2. Bacterial Metabolite

The essential secondary metabolites implicated in biocontrol by fluorescent pseudomonads are pyoluteorin (PLT), phenazines (PHZ), 2, 4-diacetylphloroglucinol (DAPG), cyclic lipopeptides (CLPs), pyrrolnitrin (PRN), and volatile natural composites (VOCs) such as hydrogen cyanide (HCN). These metabolites are recognized for antibacterial, antifungal, antiviral, antitumor, and antinematicidal properties [40]. A study in Morocco at the laboratory showed that all three fluorescent pseudomonas isolates Q110B, Q036B, and Q172B from tomato rhizospheric soil were potential biological control agents for *T. urticae*. In particular, *Pseudomonas fluorescens* isolate Q036B was the most promising applicant for biological control of *T. urticae* with a mortality rate of approximately 99% 72 h after application. For the other two strains (Q172B and Q110B), the mortality rates were similar 72 h after application and varied from 54 to 89% [41]. Besides, the *P. fluorescens* produces bacterial chitinases, which are efficient in controlling the mites by hydrolyzing their chitinous exoskeleton, the culture with cent percent of *P.*

*fluorescens* produced 100% mortality of spider mite in 24 h after application, whereas 75% culture yielded 100% mortality in 72 h, when 48 h, 50% culture was found to be least effective [42].

#### 4.2.3. Protectants Plant-Incorporated (PIP)

The extracts of plants are remarkably rich in toxins and inhibitors and can be the source of many insecticidal and acaricidal substances exploitable in the control of pests [43][44]. Black soap, brown in color, is biodegradable, non-polluting, and an excellent insecticide. This product is active on some insects such as mealy bugs, aphids, whiteflies, thrips, mites, etc. Through simple contact, it asphyxiates them while blocking the respiratory pores. Besides, it does not produce toxic residues and does not affect natural predators. These products are authorized by the specifications of organic agriculture (EEC regulation 2092/91) [45][46]. A study conducted in the Saïs region of Morocco showed that black soap was effective against several pest populations on the bell pepper crop compared to the control block [46].

The utilization of Sulfur on tomato leaves diminished *T. urticae* from 31.5 ± 6.5 individuals/15 leaves before treatment to 4 ± 0.3 [47]. This reinforces the results observed on the grapevine [48], according to which sulfur can be used to control mites while presenting low toxicity to predators. Another study under laboratory conditions confirms that sulfur is toxic against eggs of *T. urticae* [49]. In the field, the lime sulfur reduced *T. urticae* fecundity and fertility. It showed selectivity against naturally occurring predatory mites, which increases its potential as a mechanism for integrated mite management [47].

#### 4.2.4. Control with Predators

The main predators encountered in North Africa are Typhlodromus rhenanoides, Phytoseiulus persimilis (Athias-Henriot), 1957, Typhlodromus phialatus, Neoseiulus cucumeris, Neoseiulus stolidus, Feltiella acarisuga, Scolothrips longicornis, Euseius scutalis, and Euseius stipulatus.

#### ***Phytoseiulus persimilis*** **(Athias-Henriot, 1957)**

*Phytoseiulus persimilis* (Acari: Phytoseiidae) is a specialist predator that feeds particularly on *Tetranychus* species and whose survival depends on the presence and quality of its prey [27]. In Morocco, *P. persimilis* is the principal predators of *T. urticae* in the open field and in greenhouses [50], according to faunal estimations performed in 2009–2010 on strawberry plants in the Loukkos region which revealed that the mite pest *T. urticae* and its natural enemy, the predatory mite *P. persimilis*, are habitually encountered [51].

#### ***Neoseiulus californicus*** **McGregor, 1954**

The *Neoseiulus californicus* (Acari: Phytoseiidae) is a cosmopolitan species of Mediterranean climates that tolerate the higher temperatures of semi-arid to arid areas [52][53]. In Egypt, the *N. californicus* is the natural enemies associated with *T. urticae* [54]. In Morocco, the predatory mite *N. californicus* feeds on all stages of the weaver mite *T. urticae* on citrus crops [55].

#### ***Euseius stipulates*** **Athias-Henriot, 1960**

This species was described from North Africa in Algeria, Morocco, Tunisia [56]. It feeds on the red spider and eriophyid mites and consumes pollen [56]. In Tunisia, *E. stipulatus* was the most abundant species found on citrus trees (82%) [57]. Generally, this species is well represented in Mediterranean citrus orchards [58].

#### Combined Releases

In Egypt, the releasing of predators *Chrysoperla carnea* (Steph, 1836), *Orius albidipennis* (Reuter, 1884), and *P. persimilis* showed significant control of *T. urticae*, and it also assured increased crop yield as compared to pesticide application [59].

### 4.3. Physical Control

Integrated pest management should rely on an array of tactics. In reality, the use of physical control methods must be part of an integrated pest management approach. Physical controls can be classified as passive (e.g., fences, organic mulch, trenches, particle films, inert dust, and oils), active (e.g., thermal shocks, electromagnetic radiation, mechanical shocks, and pneumatic control), and miscellaneous (e.g., cold storage, heated air, flaming, hot-water immersion) [60]. Some physical methods such as oils have been used successfully for preharvest treatments for decades [61]. Another recently invented method for preharvest situations is particle films [62]. As we move from production to the consumer, legal constraints restrict the number of alternatives available. Consequently, several physical control methods are used in postharvest situations. Two notable examples are the entoleter, an impacting machine used to crush all insect stages in flour [63], and hot-water immersion, used to kill tephritid fruit flies [64].

### 4.4. Genetic Control

Genetic control is one of the methods that can replace the application of insecticides [65]. The examination of the sequenced genome of *T. urticae* will reveal the resistance mechanisms used by the mites. Moreover, the complete sequencing revealed that this genome, considered small with its 90 million bases, includes unique genes that have not yet been identified in other arthropods [66]. The researchers also identified numerous genes implicated in detoxification and digestion of toxins, which help explain the mite's unparalleled resistance to toxic compounds produced by certain plants to defend themselves, opening up the prospect of developing naturally resistant plants [67].

### 4.5. Integrated Pest Management of Tetranychus Urticae

Integrated pest management through predator and a compatible synthetic acaricide may provide an alternative strategy to chemical control of the pest [68]. Experiments were conducted on greenhouse roses to evaluate the efficacy of the nC24 petroleum spray oil (PSO), D-C-Tron in combination with *Phytoseiulus persimilis* (Acarina: Phytoseiidae) against *Tetranychus urticae* in the context of developing an integrated management program. Results showed that 0.5% PSO applied fortnightly to roses provided excellent protection against *T. urticae* infestation and did not affect the population density of *P. persimilis* in the upper and lower foliage [69]. In Brazil, on strawberry crops, control of *T. urticae* in the program based on release of *Neoseiulus californicus* (McGregor) and reduction of the frequency of acaricide applications (IPM) was effective in maintaining a significantly lower level of pest infestation, resulting in a six-fold reduction in the frequency of acaricide applications and, consequently, a reduction in selection pressure for acaricide resistance [70].

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