Vitis **28**, 97—110 (1989)

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# Differential response of grapevine cultivars to European red mite (*Panonychus ulmi* Koch) — elaboration of a screening method

by

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## Unterschiedliches Verhalten von Rebsorten gegen die Obstbaumspinnmilbe (*Panonychus ulmi* Koch) — Entwicklung einer Klassifizierungsmethode

Zusammenfassung: Die Populationsentwicklung von *Panonychus ulmi* an 16 *Vitis-vinifera*-Sorten und 5 interspezifischen Kreuzungen wurde unter Freilandbedingungen untersucht. Die Populationsdichte konnte zwischen den einzelnen Sorten erheblich variieren.

Zwischen dem Grad der Wollbehaarung auf der Blattunterseite und der Populationsdichte von *P. ulmi* wurde eine signifikante positive Korrelation festgestellt.

Die Schädigung der Rebblätter wurde aufgrund der Blattverfärbung (Bronzierung) klassifiziert. Es wurden 5 Schadstufen definiert und mit den Noten 1 (normale Blattfarbe), 3, 5, 7 und 9 (stärkste Blattverfärbung) bewertet.

Zwischen der Schadstufe der befallenen Blätter und der Populationsdichte der Milben wurde für die untersuchten Rebsorten erst zu Beginn der Beerenreife, nicht hingegen zu einem früheren Zeitpunkt der Vegetationsperiode, eine signifikante positive Korrelation festgestellt.

Ebenso zeichnete sich eine gesicherte positive Korrelation zwischen dem Grad der Wollbehaarung und der Bronzierung erst mit fortschreitender Vegetationsperiode ab.

Die Möglichkeiten der Züchtung spinnmilbentoleranter Rebsorten werden erörtert.

Key words: mites, *Panonychus ulmi*, variety of vine, leaf, damage, discoloration, test method, analysis, selection, resistance, tolerance, biological plant protection.

## Introduction

During the past few decades, increased application of nitrogen and potassium fertilizers and of non-selective pesticides in viticulture has favoured outbreaks of spider mites, which formerly were only known as occasional grapevine pests (compare Englert 1978; Schruft 1985). In moderate climates of Europe, primarily the red spider mite (*Panonychus ulmi* Koch) and, more temporarily, the two-spotted spider mite (*Tetranychus urticae* Koch) cause damage on grapevine. Heavy infestation after budburst reduces grape yield, whereas mass feeding toward grape maturity decreases berry quality. Losses of sugar may amount to 10—15 °Oe or even up to 24 °Oe (Englert 1979; Schropp *et al.* 1982).

Beside principal considerations as to environmental pollution, there are two special reasons why chemical control of spider mites should be restricted: (i) Insecticides as DDT or organophosphates and also certain fungicides promoted strains of spider mites which were resistant to these chemicals, or, moreover, their egg production could be increased (e.g. Mathys 1956; Chaboussou 1966; Schruft 1971; Dittrich 1975; Englert 1975; Schruft and Nothelfer 1978). (ii) Beneficial arthropods, especially predatory mites, which may prevent mass propagation of spider mites, are suppressed by broad-spectrum pesticides; more recently, pyrethroids showed such effects (Mathys 1956; Stellwaag-Kittler and Haub 1979; Englert and Kettner 1981; Schruft 1982; Boller 1985; Kast 1987; Schropp 1987; Steiner 1987; Englert and Maixner 1988).

The use of grapevine breedings which tolerate spider mite attack would be a strong support to integrated pest management. Development of spider mite resistant cultivars has been successful with a number of cultivated plant species, as for instance cassava, cotton, cucumber or strawberry (DE PONTI 1985). Genetic diversity, which is a prerequisite of breeding, has also been observed in the response of the genus *Vitis* to spider mites: The level of infestation by *T. urticae* and *P. ulmi* can vary between grapevine genotypes (EICHHORN and SCHREINER 1984; SCHREINER 1984). Field observations at Geilweilerhof showed regularly differences of damage by the European red mite between certain cultivars.

As a first step toward a resistance breeding programme, an efficient test method must be available. In this study, a system for classification of damage by *P. ulmi* to grapevine is proposed and correlations of the degree of damage with the mites' population density and with a morphological character of grapevine have been examined.

## Materials and methods

16 *Vitis vinifera* cultivars and 5 interspecific breedings (see Table 1), which were growing on their own roots at Geilweilerhof in a field of about 1 ha, were regularly examined for *P. ulmi* during the years 1984—88. Only from summer 1984 to spring 1986 frequent occurrence of the pest was observed, since summer 1986 it had nearly disappeared, except for cvs no. 10, 12 and 16 during 1986 and no. 10 and 16 in spring 1987. This recession may be partly due to deleterious meteorological conditions — e.g. exces-

Table 1

List of the grapevine cultivars examined

Verzeichnis der untersuchten Rebsorten

| No. | Cultivar | No. | Cultivar |
|---|---|---|---|
| *Vitis vinifera* cvs | | *Vitis vinifera* cvs | |
| 1 | Bacchus | 16 | Gf. 3-28-45 |
| 2 | Comtessa | 17 | Gf. 3-28-51 |
| 3 | Domina | 18 | Gf. 37-28-75 |
| 4 | Forta | | |
| 5 | Gloria | | |
| 6 | Morio-Muskat | | |
| 7 | Müller-Thurgau | Interspecific crossings | |
| 8 | Optima | 19 | Pollux |
| 9 | Gf. Koe-49-81 (a) | 20 | Phoenix (Gf. Ga-49-22) |
| 10 | Gf. Koe-49-81 (b) | | |
| 11 | Gf. Koe-50-100 | 21 | Sirius (Gf. Ga-51-27) |
| 12 | Gf. Koe-70-4 | | |
| 13 | Gf. Koe-70-96 | 22 | Gf. Ga-54-14 |
| 14 | Gf. 1-25-4 (a) | 23 | Orion (Gf. Ga-58-30) |
| 15 | Gf. 1-25-4 (b) | | |

(a) and (b) at no. 9/10 and 14/15 mean duplicate planting in separate plots.

sively high temperatures in summer 1986 or a cool and wet spring 1987 — or also to the presence of predatory mites, whereas influence of pesticides is to be excluded.

The data presented in this paper are based on samples taken at the following times: (I) 5 August 1985, beginning of 'bunch closure'; (II) 25 September 1985, onset of berry maturity, or harvesting maturity of early ripening varieties, respectively; (III) 22 January 1986, winter dormancy; (IV) 15 May 1986, stage of 3—5 fully expanded leaves.

The experimental plots did not receive any application of acaricides, insecticides or of fungicides with activity against spider mites. During the growing season 1985, competing *T. urticae* or predators of *P. ulmi*, as *Typhlodromus pyri*, *Orius minutus*, *Chrysopa carnea*, were just rarely observed. However, part of the winter eggs at time III showed injuries which indicated feeding activity by larvae of Chrysopids. Damages due to excessive water conditions, nutritional deficiencies or virus diseases, which could have influenced the coloration of sampled leaves, did not occur in 1985.

At sampling dates I and II, 25 fully grown leaves/cv. were randomly collected at half height of the canopy. After noting the degree of discoloration (as an index of leaf damage, see below), the leaves were freeze-stored until evaluation of mite populations. The procedure was similar with the basal leaves of the 3—5 leaf stage (date IV), except that leaf damage was not classified. Winter eggs (date III) were evaluated from 25 cane pieces/cv., each comprising the nodes 3—5 from the base (compare SCHRUFT *et al.* 1978; SENGONCA *et al.* 1984).

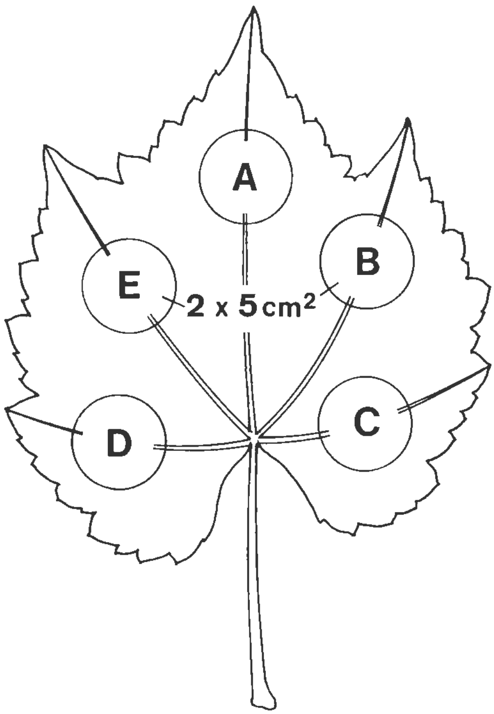


Fig. 1: Position of 5 cm² leaf discs tested for determination of population frequency of *P. ulmi* on grapevine. Values calculated from discs B + E of 25 leaves/cv. are representative for the whole leaf area.

Die Position der 5 cm² großen Blattscheiben, aus denen probeweise die Populationsdichte von *P. ulmi* auf Rebblättern bestimmt wurde. Die aus den Scheiben B + E errechneten Werte von 25 Blättern/Sorte sind für die gesamte Blattfläche repräsentativ.

The density of prostrate (downy) hairs between the veins on the lower leaf side was estimated according to O.I.V. guideline no. 084 (O.I.V. 1983). This code uses a scale of 1, 3, 5, 7 and 9 points, where note 1 means no or very few hairs (example Rupestris du Lot) and note 9 stands for extremely dense downy hairs (*V. labrusca*).

The most obvious sympton of damage by *P. ulmi* is the 'bronzing' of infested leaves. Therefore, damage assessment was based on the extent of leaf discoloration — yellow to brown or reddish hues in white or red wine grapevines, respectively. Five classes of damage are defined as follows:

Note 1: Normal colour

Note 3: Isolated yellowish or reddish discoloration; normal green colour is prevailing on leaves

Note 5: The rate of discoloured and normally green leaf parts is balanced

Note 7: Green coloration is confined to leaf parts near to the veins

Note 9: No green colour visible, premature senescence of leaf

(The latter class was only observed in summer 1984.)

Damage assessment was supported by comparison with a series of colour photographs.

When estimating the frequency of *P. ulmi* on the leaves, the eggs were recorded separately and larvae, protonymphs, deutonymphs and adults were summarized as 'mobile stages'. Direct counting of mite stages *in situ* was, due to its exactness, preferred to other registration techniques as brushing machine or washing off. For population counts in the 3—5 leaf stage, the whole basal leaves were inspected and their areas measured by use of a LI-COR LI-3100 area meter. Records on mature leaves were confined to the both leaf discs B and E shown in Fig. 1, with an area of 5.0 $cm^2$ each, because tests using 6 cultivars had shown that the calculated values of mite density (based on 2 × 25 discs/cv.) differed only by maximum ± 2 % from the data determined from the total leaf area.

As is shown by Table 2, mite stages were not only present on the lower leaf side (L), but were also found on the upper surface (U). The ratios L : U varied from 2.5 to 17.9 for the mobile stages and between 1.0 and 7.0 for the eggs. The counts, therefore,

Table 2

Distribution of *P. ulmi* on the lower (L) and upper (U) surfaces of grapevine leaves · Greenhouse, 15 July 1985

Verteilung von *P. ulmi* auf der Unterseite (L) und Oberseite (U) von Rebblättern · Gewächshaus, 15. Juli 1985

| Cultivar | Ratio L : U | | |
|---|---|---|---|
| | Mobile stages | Eggs | All stages |
| Kerner | 2.5 | 3.2 | 2.6 |
| Vidal 256 | 4.6 | 1.0 | 2.5 |
| Pollux | 4.1 | 2.5 | 3.1 |
| Phoenix | 3.7 | 3.4 | 3.2 |
| Sirius | — | — | 8.6 |
| Gf. Ga-48-12 | — | — | 6.8 |
| Gf. Ga-50-25 | 17.9 | 2.0 | 4.8 |
| Gf. Ga-58-14 | — | — | 3.3 |
| Gf. 67-451-1 | 9.3 | 7.0 | 8.3 |

considered both leaf sides. Data of population frequency, expressed as n/100 $cm^2$ of leaf area, refer, however, to the simple leaf surface.

Together with the stages of red spider mites, also possible arthropod enemies were registered. To detect predatory mites, the petiolar sinus with the origins of the main leaf veins was additionally examined.

When counting the winter eggs, data of which are based on 75 nodes/cv. (see above), vital (red coloured) and dead (white) eggs were separately recorded.

## Results and discussion

### 1. Seasonal changes of spider mite populations

Fig. 2 shows, due to samples taken at times I—IV, the development of *P. ulmi* populations on the several cultivars from summer 1985 to spring 1986. In midsummer (date I), frequently over 50 % of the mite stages were eggs, indicating strong propagation during this time. Toward late summer (II), oviposition on the leaves obviously began to cease, as generally less than 10 % of the total population were summer eggs. Indeed, a number of females must have moved to the canes and laid eggs around the base of the petioles. Among the winter eggs sampled toward the end of January (III), on average half were white, i.e. dead. As mentioned above, part of these eggs had probably been emptied by Chrysopid larvae. (According to HAUB *et al.* (1983), already in autumn more than 50 % of the winter eggs of *P. ulmi* were destroyed by larvae of *Chrysopa carnea*.) In the following spring (IV), populations on the basal leaves of young shoots comprised exclusively the animals hatched from the winter eggs, as no fresh summer eggs or their empty shells were present.

The mean population densities over all cultivars were: (I) 299 mite stages/100 $cm^2$ of leaf area (varying from 10 to 751 stages between cultivars); (II) 230 stages/100 $cm^2$ (50—549); (III) 43 winter eggs/node (3—126); (IV) 252 mobile stages/100 $cm^2$ (6—1493). When comparing these figures, the differing substrates must be taken into account, namely matured leaves at times I and II, nodes of woody canes (III) and growing young leaves (IV). Significant correlations existed between the population frequencies observed at sampling dates following each other (I—II: r = 0.574**; II—III: r = 0.702**; III—IV (red winter eggs only): r = 0.864**). From these correlations it can be concluded that, except mortality of winter eggs, the population development during the observation period was not markedly disturbed by external factors.

At a given sampling time, considerable difference of mite infestation could be stated between the several cultivars. A constantly low level of infestation (10—60 stages/100 $cm^2$ of leaf area) was registered on cvs Domina (no. 3) and Gf. Koe-70-96 (13). Leaves of other cultivars, on the contrary, were at least once settled by more than 500 stages/100 $cm^2$ (1, 2, 4, 8, 9, 10, 14, 15, 16, 18, 23). The remaining 10 cultivars (5, 6, 7, 11, 12, 17, 19, 20, 21, 22) showed intermediate population densities on their leaves. On cvs Gf. Koe-49-81 (9, 10) and Gf. 1-25-4 (14, 15), which were both planted in duplicate, population development was rather similar in the different plots.

### 2. Downy hairs of leaves and spider mite development

According to SCHREINER (1984), *P. ulmi*, as well as *T. urticae*, prefers grapevines provided with tight prostrate (downy) hairs and few erect (bristle-like) hairs on the lower leaf surface. In the present investigation, a positive correlation significant at the 1 % level between the density of downy hairs (between veins) and population frequency (all stages together) has also been stated at time I and, a little bit lowered, at

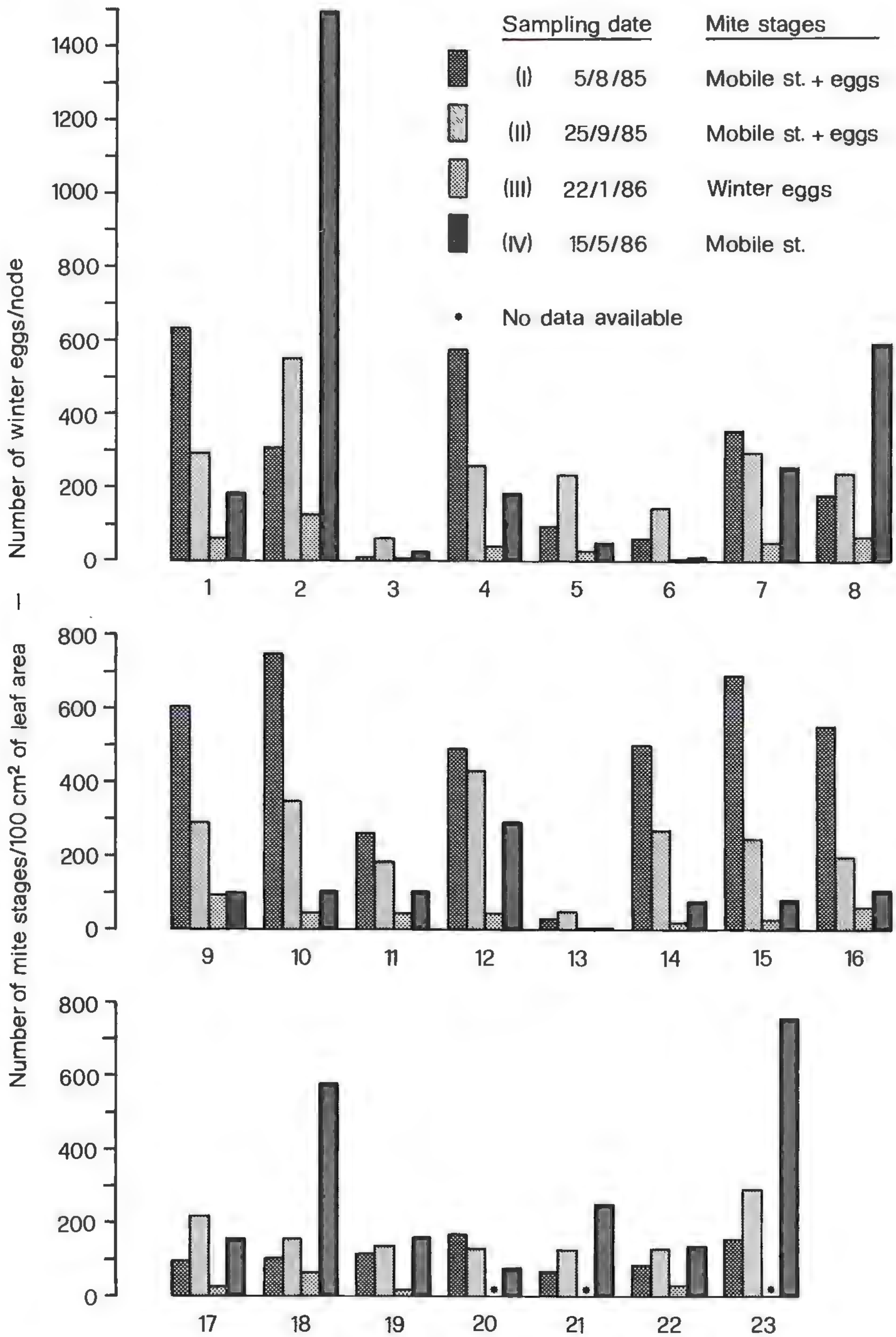


Fig. 2: Population frequencies of *P. ulmi* on leaves of different grapevine cultivars at 4 sampling dates. For code no. of cultivars see Table 1.
Populationsdichte von *P. ulmi* auf den Blättern verschiedener Rebsorten; 4 Probenahmetermine. Nr. der Rebsorten s. Table 1.

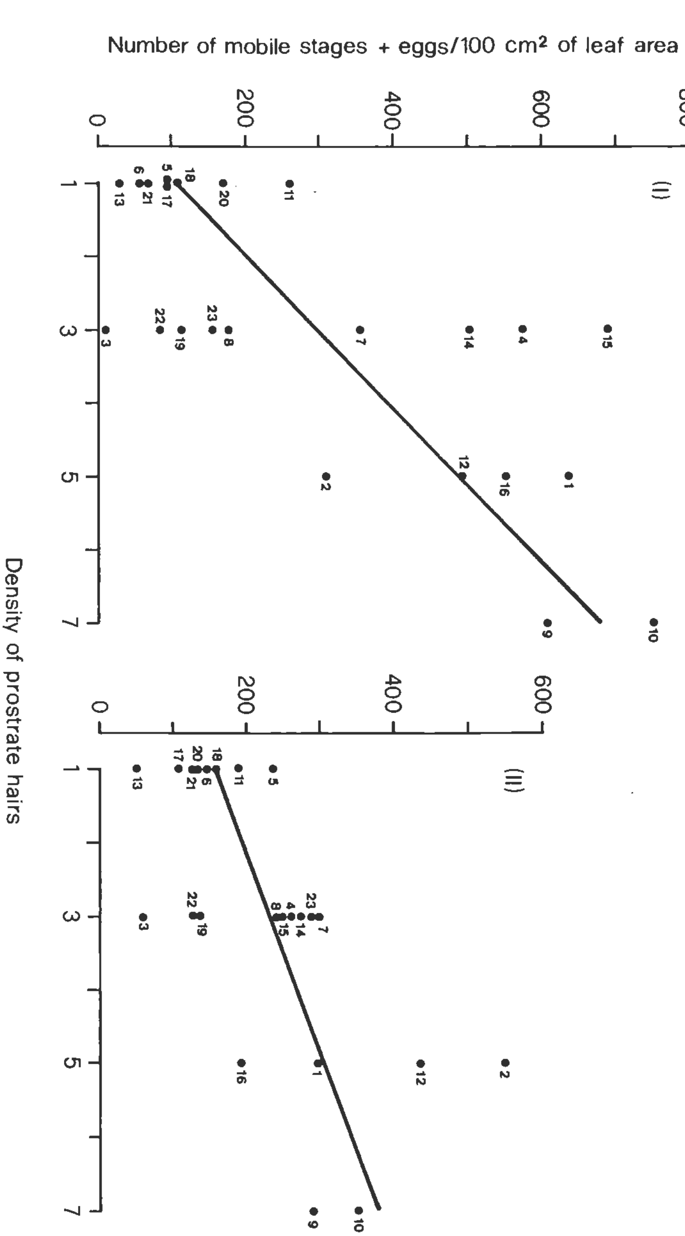


Fig. 3: Interrelationship between density of prostrate hairs on the lower leaf side of grapevine cultivars and population frequency of *P. ulmi* (all stages) at sampling dates I and II. Code no. of cultivars see Table 1. — (I) : $y = 12.9 + 95.4\,x$, $r = 0.747$**; (II): $y = 117.0 + 37.8\,x$, $r = 0.622$**.

Die Beziehungen zwischen der Dichte der Wollbehaarung auf der Blattunterseite von Rebsorten und der Populationsdichte von *P. ulmi* (sämtliche Stadien) zum Zeitpunkt I und II. Nr. der Rebsorten s. Table 1.

time II (Fig. 3). Correlation of hair density was best with the number of eggs laid at date I (Fig. 4, r = 0.817 * *). At date II, the interrelationship downy hairs — eggs could not be stated any longer, probably due to an increased attractiveness of shoot nodes as oviposition sites. Dense down covering leaves may protect mobile stages and eggs against removal by rain and wind, maintain higher air humidity and satisfy the mites' tactile needs, thus contributing to prolonged feeding and increased fecundity.

### 3. Leaf discoloration of grapevine cultivars as an index of damage by *P. ulmi*

At sampling date I, the majority of cultivars was scored in the range of 3—4 points, i.e. discoloration was still slight. Some cultivars tended to a leaf damage index of 5 (intermediate), others were just weakly affected (< 3 points). The latter ones were the interspecific breedings Pollux (19), Sirius (21), Phoenix (20), Orion (23) and the *V. vinifera* cv. Gf. Koe-70-96 (13) (see Fig. 5). At date II, symptons of damage had intensified with all grapevines. Cvs no. 19, 13 and 21, not exceeding degree 4, had maintained their relative position. Most varieties were within the range 4—6. 6 cultivars showed more severe damage (> 6.5 points). Damage indices of cvs no. 9/10 and 14/15 examined in duplicate showed good agreement between the different plots (9/10: (I) 4.0/4.4, (II) 6.9/ 6.7; 14/15: (I) 3.2/3.2, (II) 5.3/5.4). Within the examined collective of grapevine genotypes, significance existed between discoloration at dates I and II (Fig. 5, r = 0.647**).

In spring 1986 (date IV), duration of feeding had been too short to effect marked leaf discoloration, apart from darkening of the leaf teeth, which has been used for diagnosis of early attack by *P. ulmi* (SCHRUFT 1983).

The increase in discoloration of a leaf together with progress of the growing season and prolonged feeding of red spider mite must be considered in practical screening work. To be fully expressed, damage should be assessed as late as possible, but well before the onset of senescence. This condition is given at the beginning of grape maturity, when berries are becoming soft.

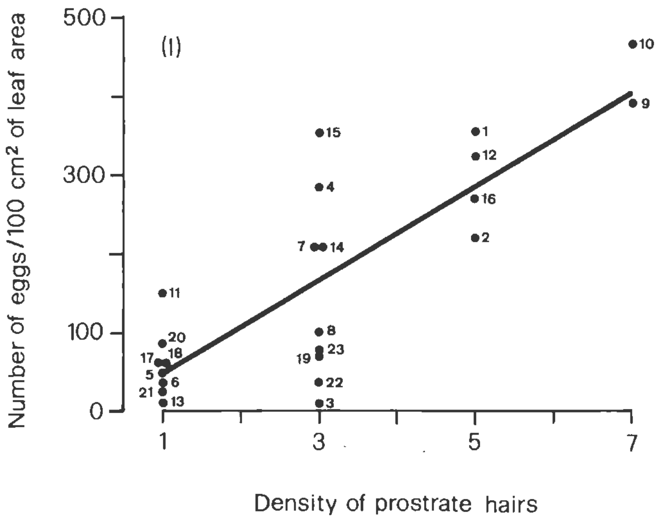


Fig. 4: Interrelationship between density of prostrate hairs on the lower leaf side of grapevine cultivars and frequency of eggs laid by *P. ulmi* at sampling date I. Code no. of cultivars see Table 1. — $y = -11.5 + 59.8x$, r = 0.817**.

Die Beziehungen zwischen der Dichte der Wollbehaarung auf der Blattunterseite von Rebsorten und der Dichte der von *P. ulmi* abgelegten Eier zum Zeitpunkt I. Nr. der Rebsorten s. Table 1.

### 4. Interrelationship between discoloration of leaves and population frequency of *P. ulmi*

As is to be seen from Fig. 6 (I), at sampling date I on average of cultivars no significant correlation existed between population frequency and score of leaf damage. This is the case not only for all mite stages together, but also for mobile stages or eggs alone. With progress of growing season and duration of stress by the feeding mites (date II), however, a significant correlation appeared (Fig. 6 (II), r = 0.669 **). Nevertheless, single cultivars may deviate considerably from this general trend.

### 5. Interrelationship between leaf discoloration by *P. ulmi* and prostrate hairs of leaves

Similarly as shown before, at time I no correlation could be confirmed between the two features, whereas it was significant at time II (Fig. 7, r = 0.629 **). From the findings on the grapevines studied in this paper as well as from the work of SCHREINER (1984), probability exists that cultivars having downy leaves are generally more endangered by *P. ulmi* than grapevines with bald leaves, though the character 'prostrate hairs' cannot replace examination of the single cultivars for their reaction to spider mite infestation.

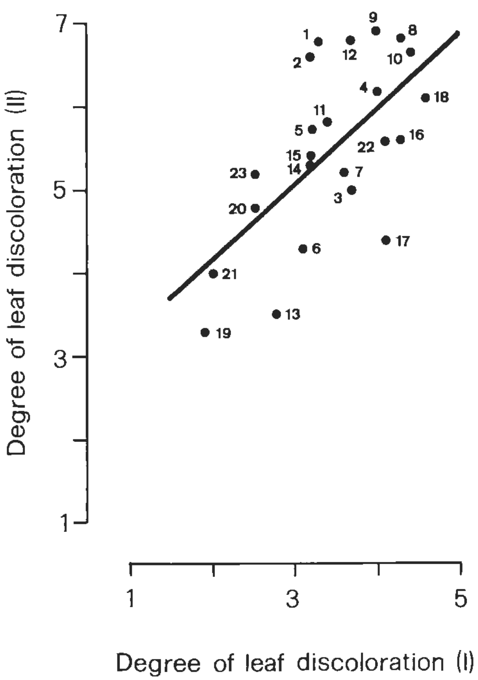


Fig. 5: Interrelationship between degrees of leaf discoloration due to *P. ulmi* at sampling dates I and II. Code no. of cultivars see Table 1. — y = 2.39 + 0.91 x, r = 0.647**.

Die Beziehungen zwischen dem Grad der durch *P. ulmi* verursachten Blattverfärbung zu den Zeitpunkten I und II. Nr. der Rebsorten s. Table 1.

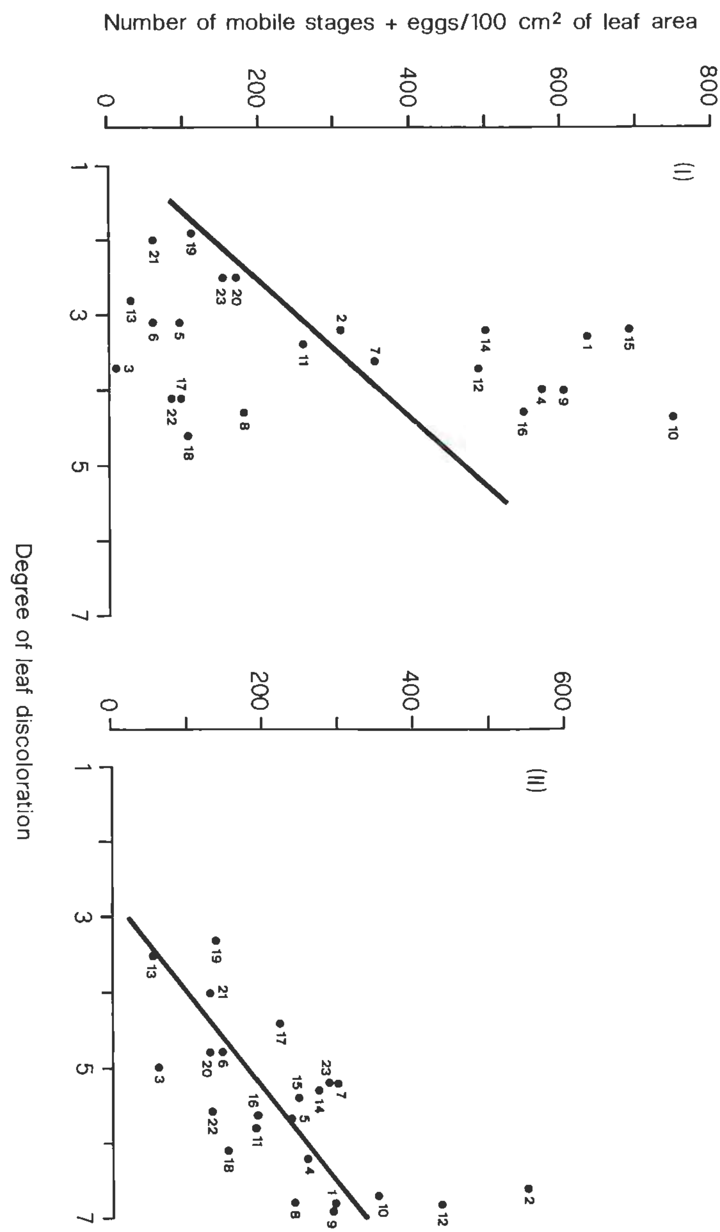


Fig. 6: Interrelationship between degree of leaf discoloration and population frequency of *P. ulmi* at sampling dates I and II. Code no. of cultivars see Table 1. — (I): $y = -80.0 + 110.4\,x$, $r = 0.341$ NS; (II): $y = -173.8 + 73.5\,x$, $r = 0.669^{**}$.

Die Beziehungen zwischen dem Grad der Blattverfärbung und der Populationsdichte von *P. ulmi* zu den Zeitpunkten I und II. Nr. der Rebsorten s. Table 1.

## Conclusions

As pointed out earlier, during 1985 population development of *P. ulmi* on grapevine leaves was obviously not disturbed by environmental factors, nor were the host plants under additional stress. Therefore, the feeding activity of red spider mite must be the

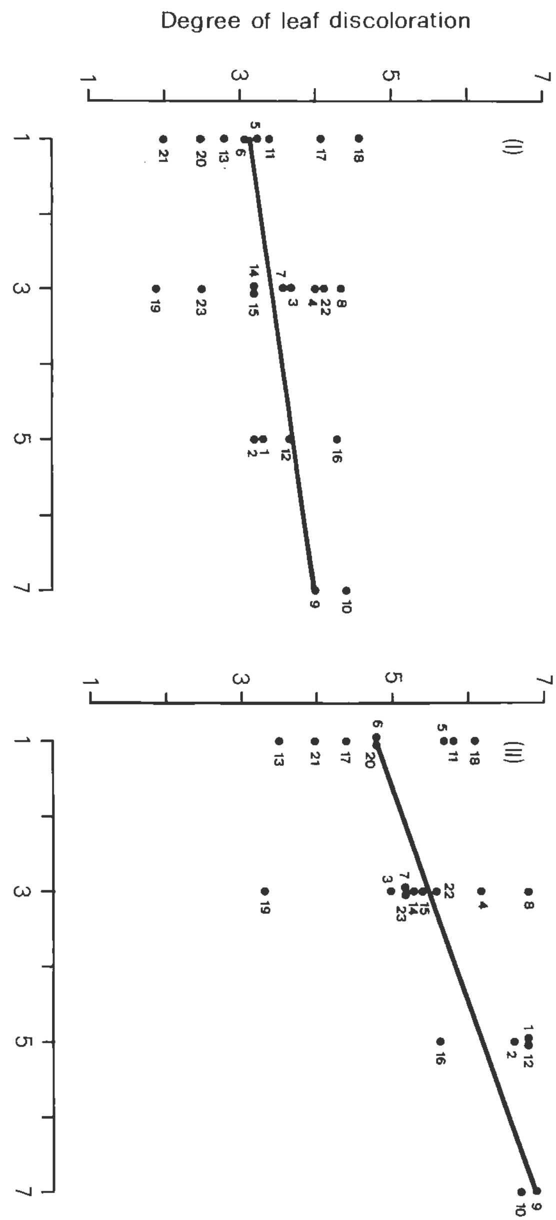


Fig. 7: Interrelationship between density of prostrate hairs on the lower leaf side and the degree of leaf discoloration due to *P. ulmi* at sampling dates I and II. Code no. of cultivars see Table 1. — (I): $y = 3.02 + 0.14x$, $r = 0.356$ NS; (II): $y = 4.46 + 0.35x$, $r = 0.629^{**}$.

Die Beziehungen zwischen der Dichte der Wollbehaarung auf der Blattunterseite und dem Grad der durch *P. ulmi* verursachten Blattverfärbung zu den Zeitpunkten I und II. Nr. der Rebsorten s. Table 1.

primary cause of the leaf discoloration observed and gradual differences between cultivars reflect the differential response of genotypes to spider mite attacks. As the observations could not be repeated over several years, the relative character of the damage scores obtained for the several cultivars must be emphasized. On the other hand, variation of damages allowed the establishment of a classification system — which was the primary aim of this work.

According to DE PONTI (1977, p. 637), who in a series of papers investigated the response of *Cucumis sativus* to *T. urticae*, "two basically different mechanisms of a plant to withstand a parasitic attack can be distinguished: resistance (vs. susceptibility) and tolerance (vs. sensitivity). . . . . . *Resistance* is the complex of characters of a host that reduces the reproduction of a parasite. *Tolerance* is the ability of a host to endure the occupation by a parasite." (see also DE PONTI 1985; FRITZSCHE *et al.* 1988).

Adopting these definitions, among *Vitis* genotypes a broad spectrum of resistance to *P. ulmi* (expressed by population density, Fig. 2) as well as different degrees of tolerance or sensitivity, respectively (the latter assessed by leaf discoloration, Fig. 5), could be observed. For certain cultivated plants like ornamentals or leafy vegetables, high tolerance to feeding damages by spider mites without simultaneous restriction of reproduction can surely not be accepted. In grape production, however, planting of spider mite tolerant cultivars — their threshold of economic damage to be determined — would be quite sufficient, especially if it were accompanied by protection of natural enemies. Tolerant new grapevine breedings could be achieved in a shorter time than resistant ones, which, moreover, could be attacked by newly emerging strains of the pest. According to SCHREINER (1984), responses of grapevine cultivars to *P. ulmi* and *T. urticae* run about parallel; thus breedings which are tolerant to *P. ulmi* might also tolerate infestation by *T. urticae.*

From the above it is clear that estimation of population frequency is not an adequate screening procedure when breeding for tolerance to red spider mite, apart from being laborious and time-consuming. However, assessment of leaf discoloration — obtained under standardized conditions — can be used as a simple and quick method of damage classification. Pre-selection of breeding parents could also make use of the character 'prostrate hairs' on leaves, which is negatively correlated with tolerance of grapevine cultivars.

As indicated earlier, at Geilweilerhof field tests failed during several years, probably due to harmful weather conditions and spread of natural enemies of *P. ulmi.* In non-conditioned greenhouses, on the other hand, excessively high summer temperatures were lethal to red spider mite, though test plants had been successfully inoculated. Temperature-controlled greenhouses would therefore be a prerequisite of reliable and efficient tests.

In a following paper, histological and physiological aspects of damage caused by *P. ulmi* on grapevine shall be presented and the proposed test method, based on visual scoring, be compared versus objective measurement.

## Summary

Population development of the European red mite, *Panonychus ulmi* KOCH, was studied in the field on 16 *Vitis vinifera* cultivars and 5 interspecific crosses. Population frequency could considerably vary between cultivars.

A significant positive correlation existed between the density of prostrate (downy) hairs on the lower leaf surface and the population frequency of *P. ulmi.*

The degree of leaf damage due to feeding of mites was visually estimated according to the extent of leaf discoloration (bronzing). 5 classes of damage were distinguished and scored by the indices 1 (normal colour), 3, 5, 7 and 9 (most advanced discoloration).

Among the grapevine genotypes examined, a significant positive correlation between the degree of leaf damage and the population frequency of *P. ulmi* was stated toward the onset of grape maturity but not earlier in the growing season.

Similarly, a positive correlation between density of prostrate hairs and discoloration of infested leaves was observed only later in the growing season.

Perspectives of breeding grapevine cultivars which are tolerant to attack by *P. ulmi* are discussed.

## Acknowledgements

The author wants to thank Mrs. CH. GLEICH for careful technical assistance and Dr. M. KLENERT for help with the statistical analyses and meteorological data.

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*Eingegangen am 16. 2. 1989*

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