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Comparative biology and fertility parameters of two spotted spider mite, *Tetranychus urticae* Koch. on different grapevine varieties

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Summary

The influence of the four grapevine varieties 'Thompson Seedless', 'Manjri Naveen', 'Gulabi' and 'Bangalore Blue' on fitness, development and reproductive characteristics of the two spotted spider mite, *Tetranychus urticae* was studied. The biology of two spotted spider mites consisted of egg, larvae, protonymph, deutonymph and adult stages. The total duration from egg to adult was found to be the least in 'Thompson Seedless' (16.2 days) followed by ''Manjri Naveen' (17.2 days), 'Gulabi' (17.2 days) and maximum in 'Bangalore Blue' (32.2 days). The survival rate of life stages of mites was found to be lower in 'Bangalore Blue'. The higher values of net reproductive rate, intrinsic rate of increase, finite rate of increase the shortest mean generation time was observed in 'Thompson Seedless' followed by 'Gulabi', 'Manjri Naveen' and 'Bangalore Blue'. The results suggested that 'Thompson Seedless' was the most suitable cultivar with higher survival rate of life stages of mites, shortest development period, higher value intrinsic rate of increase and fecundity whereas 'Bangalore Blue' was the least suitable cultivar because of the lowest intrinsic rate of increase, longest development period, lower survival rate of life stages of mites.

K e y w o r d s : two spotted spider mite; life table; intrinsic rate of increase; *Tetranychus urticae;* grapevine.

Introduction

The nymphs and adults of mites prefer older leaves of the plant and suck the sap from under surface of the leaves. The infested leaves turn yellowish with loss of chlorophyll, developing brownish patches which ultimately results in withering and drying (Kulkarni *et al.* 2008). Under severe infestation, the leaves get discoloured with profuse webbing of the leaves. Chlorophyll content of the leaves is regarded as one of the parameters determining the photosynthetic efficiency of the plant (Lahai *et al.* 2003). Chlorosis is the obvious symptom caused by the mite feeding injury which is indicative of the loss of chlorophyll content of the leaves. Mite densities of 20, 35 and 60 mites per leaf in grapevine caused a reduction in and total chlorophyll content up to 20, 27.5 and 48.57 %, respectively, as compared to leaves with zero mite population (unpubl. data). Reduction in chlorophyll content might directly negatively impact the photosynthetic rate of the vines. Mites being a pest with shorter life cycle capable to have multiple overlapping generations need chemical sprays at frequent intervals that in turn aggravates the situation. Higher populations of mites cause severe defoliation along with reduced sugar content and desaping of the berries.

The present mite management strategy under Indian viticulture system solely relies upon the use of sulphur based acaricides. Mites are the pests of the late season in grapevine under Indian conditions. The over dependence on acaricides is a risky venture that results in resistance development of the mites. Two spotted spider mite, *T. urticae* showing resistance to lime sulphur in okra has been reported by Karthick *et al.* 2009. Use of sulphur based acaricides may eliminate the native neuropteran predators and predatory mites resulting in the sudden flare of mite population. The toxicity of lime sulphur towards the growth and development of *Chrysoperla externa* and predatory mite, *Amblyseius herbicolus* was reported by Venzon *et al.* 2013.

Use of varieties/cultivars resistant to insect pests may reduce the load of pesticides usage over the crop. Indirectly cultivars on which insects show prolonged growth and development may expose the insect to the potential natural enemies resulting in natural control of insect population (Sarfraz *et al.* 2007). Life-table parameters, including net reproductive rate (R_o), mean generation time (T), doubling time (DT), finite rate of increase (λ) and intrinsic rate of natural increase (r_m) have been used to evaluate the susceptibility or resistance of several host plants in relation to various pests (Tsai and Wang 2001). The study helps to identify the trend in population growth rate of the insect in the current and the next generation which is an essential decision making tool in developing an efficient insect management strategy (Frel *et al.* 2003). Among these parameters, the intrinsic rate of increase is commonly used to evaluate the level of plant resistance to insects. Host plants with lower values of r_m are relatively more resistant than the plants with higher values of rm. Little information is available on the host plant resistance to grapevine mites. Variations

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in the level of infestation and development parameters of mites on the cultivars of grapevine are observed under field conditions. However, the influence of grapevine varieties on the life history parameters of mites was not thoroughly studied. Life table studies provide information about the suitability of the host plant for the growth and development of the insect. The growth, development, fecundity rates and mortality factors of insect pests and phytophagous mites is greatly influenced by the variety, host plant nutritional status, phenological stage, physico-chemical properties of the host plant or cultivar (Razmjou *et al.* 2009). The present study was undertaken to investigate the life history parameters of two spotted spider mites, *T. urticae* in selected four varieties of grapevine.

Material and Methods

Mass culturing of two-spotted spider mites: Two-spotted spider mites were collected from the infested grape leaves and inoculated on potted okra plants maintained at 28 ± 2 °C and 75 ± 2 % RH at the insectary. After establishment of the culture, the mites were collected and used for the bioassay studies.

Grapevine varieties used for the study: Of the four varieties of grapevine, three were *Vitis vinifera* cultivars *i.e.* 'Thompson Seedless', 'Manjri Naveen' (clonal selection of Centennial Seedless), 'Muscat of Hamburg' (popularly known as 'Gulabi') and one was *V. labrusca i.e.* 'Bangalore Blue'. They were screened for the incidence of mites in the germplasm block of ICAR-National Research Centre for Grapes (NRCG). The own rooted plants of the respective varieties were obtained from the nursery of ICAR-NRCG and planted in plastic pots. One year old plants at appropriate stage were used for various experiments.

Studies on biology of two spotted spider mite, *T. urticae* on selected varieties of grapevine: The biology of mites was studied on 'Thompson Seedless', 'Manjri Naveen', 'Gulabi' and 'Bangalore Blue'. Leaf discs (60 cm diameter) of the respective varieties were prepared and placed over a layer of filter paper in a petri dish (100 mm diameter). Ten eggs of mites were collected from the respective stock culture using a fine camel hair brush and released over the leaf discs. Five replicates were maintained for each treatment. The leaf discs were replaced at regular intervals before they dried out. The duration of each life stage of mites and total time taken to complete egg to adult stage was recorded.

Oviposition and demographic parameters of two spotted spider mites, *T. urticae*: One year old own rooted plants of the four varieties were maintained in plastic pots and used for the life table studies. Hundred eggs were collected from the stock culture using camel hair brush and released randomly over the mature leaves. Five replicates each with twenty eggs were maintained for each variety of grape vine. The observations on the survival and development of each life stage of mites were recorded. The duration of the development of each stage was recorded based on the observed exuviae of the previous life stage. The number of each instar moulted successfully to the next instar and duration of each instar were recorded. The number of mites found dead in each life stage was recorded. The reason for the mortality was also recorded.

The adult females emerged were collected using a camel hair brush and released over the leaf discs of the respective varieties for feeding and oviposition. The day of start of egg laying, number of eggs laid by a female and the longevity of the adult females were recorded. The survival and fecundity of each female was recorded till the death of the last female. The following reproductive parameters were calculated based on the recorded data on the fertility and survival schedules.

Net Reproductive Rate $R_0 = \Sigma lxmx$,

Mean Generation Time, $T_G = \Sigma xlxmx / \Sigma lxmx$,

Intrinsic Rate of Increase = $\log R_0 / T_G$

Finite Rate of Increase = $\lambda \exp (r_m)$

Doubling time = $\log 2 / r_m$

Where x indicates the pivotal age for the class in units of time, lx indicates number of females surviving at the beginning of age class x, mx indicates total number of eggs laid by a female and lx mx indicates total number of eggs laid by a female in age class x.

Statistical analyses: The duration of life stages of mites, reproduction and fecundity parameters were compared between the four varieties and one way analysis of variance was done in Tukey's HSD method (0.05%) using SAS 9.3 software. The values of life table parameters were analyzed for one way ANOVA and the means were compared using Tukey's method.

Results

Biology of two spotted spider mite, *T. urticae* on grapevine varieties: The lifecycle of *T. urticae* consisted of egg, larva, protonymph, deutonymph and adult stages (Tab. 1, Figure). The egg was translucent and white in colour, which gradually turned to creamy white in colour near hatching. The mean duration of egg stage was 2.2, 4.4, 6.0 and 3.4 d in 'Thompson Seedless', 'Manjri Naveen', 'Bangalore Blue' and 'Gulabi' respectively. Highest percent hatchability of eggs were recorded in 'Thompson Seedless' (88.2) followed by 'Gulabi' (87.2), 'Manjri Naveen' (83.2) and the least in 'Bangalore Blue' (65.8) (Tab. 2). The newly emerged larvae were spherical in shape and creamy yellowish white in colour with two bright and prominent red spots on the dorsal sides with three pairs of legs. The duration taken to complete the larval stage was 3.4 d in 'Thompson Seedless' and 'Manjri Naveen', 4.6 d in 'Bangalore Blue' and 2.2 d in 'Gulabi'. The duration of the larva was longest in 'Bangalore Blue' and the shortest in 'Gulabi'. The survival percentage of the larvae was 87.04, 84.55, 84.65 and 75.07 percent in 'Thompson Seedless', 'Manjri Naveen', 'Gulabi' and 'Bangalore Blue' respectively. The protonymph appeared pale white in colour which turned to straw yellow near maturity with four pairs of legs. There was a clear difference in the mean duration taken to complete the protonymphal stage

Table 1

Life cycle of two spotted spider mite, *Tetranychus urticae* on grapevine varieties

Life stages of two spotted spider mite, *T. urticae*	Duration of different life stages on different varieties of grapevine Mean ± SD (d) n = 50			
	Thompson Seedless	Manjri Naveen	Bangalore Blue	Gulabi
Egg	2.2 ± 0.84	4.4 ± 1.14	6.0 ± 2.0	3.4 ± 0.89
Larva	3.4 ± 0.89	3.4 ± 1.82	4.6 ± 0.89	2.2 ± 0.84
Proto nymph	2.6 ± 0.89	2.4 ± 1.14	5.8 ± 1.92	4.6 ± 1.67
Deutonymph	2.4 ± 0.89	2.6 ± 1.52	6.2 ± 1.48	3.0 ± 0.71
Adult	5.6 ± 1.14	4.4 ± 1.14	8.6 ± 0.89	4.6 ± 1.67
Fecundity	173.4 ± 17.02	93.6 ± 12.07	40.8 ± 1.79	120.1 ± 1.10
Egg to Adult	16.2 ± 1.02	17.2 ± 4.08	32.2 ± 3.96	17.2 ± 4.147

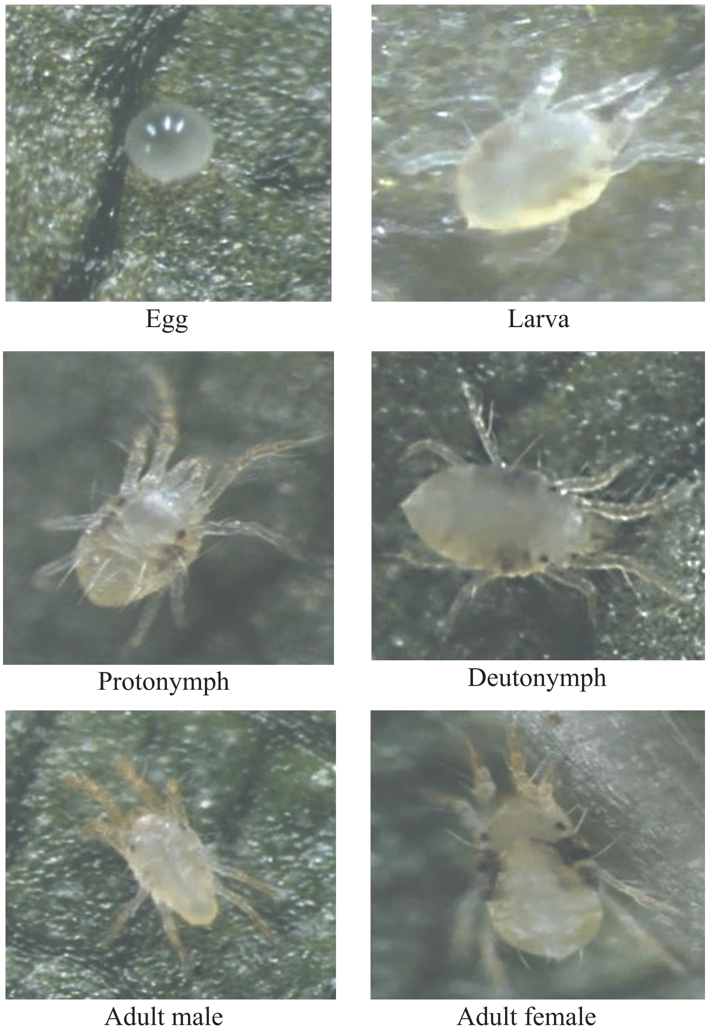

Figure: Life stages of *Tetranychus urticae* Koch.

Table 2

Survival rate of life stages of two spotted spider mite, *T. urticae* on different grape varieties

Varieties	Egg hatchability (%)	Survival rate in larvae (%)	Survival rate in protonymph (%)	Survival rate in deutonymph (%)	Survival rate in adult (%)
Thompson Seedless	88.2	87.042	86.722	82.378	82.032
Manjri Naveen	83.2	84.554	86.528	79.262	81.512
Gulabi	87.2	84.646	82.812	82.314	84.386
Bangalore Blue	65.8	75.066	76.186	72.796	78.136

between the varieties tested, 2.6, 2.4, 5.8 and 4.6 days in 'Thompson Seedless', 'Manjri Naveen', 'Bangalore Blue' and 'Gulabi' respectively. The survival percentage of protonymphs was found to be highest in 'Thompson Seedless' (86.72 %) followed by 'Manjri Naveen' (86.53 %), 'Gulabi' (82.81 %) and least in Bangalore Blue (76.19 %). After the protonymphal stage, the mites entered into the deutonymphal stage which appeared very similar to protonymph except for the size. The deutonymphal stage lasted for 2.4, 2.6, 6.2 and 3.0 d with a survival rate of 82.38, 79.26, 72.91 and 82.31 percent on 'Thompson Seedless', 'Manjri Naveen', 'Bangalore Blue' and 'Gulabi' respectively.

Adult mites were broad with a pair of distinct spots on either side of the dorsum. The first pair of legs was longer than the rest of the pairs in adult. The abdomen of the adult male is narrow. Males appeared comparatively smaller than the females. The adult males were usually spotted near the deutonymphs nearing maturity as preparedness for mating. The duration of adult mites was 5.6, 4.4, 8.6 and 4.6 d with a survival rate of 82.03, 81.51, 78.14 and 84.39 % in 'Thompson Seedless', 'Manjri Naveen', 'Bangalore Blue' and 'Gulabi' respectively. The duration taken to complete egg to adult stage was 16.2, 17.2, 32.2 and 17.2 d in 'Thompson Seedless', 'Manjri Naveen', 'Bangalore Blue' and 'Gulabi' respectively. The longevity of the adult stage was 10.4, 4.8, 2.8 and 1.4 d in 'Thompson Seedless', 'Manjri Naveen', 'Gulabi' and 'Bangalore Blue'. The lifecycle of mites found to vary from 16-32 d on different varieties *viz.*, shortest on 'Thompson Seedless' (16.2 d) followed by 'Manjri Naveen' (17.2 d), 'Gulabi' (17.2 d) and 'Bangalore Blue' (32.2 days). Thus the life span of the mites was the shortest on 'Thompson Seedless', 'Gulabi' and 'Manjri Naveen' and the longest in 'Bangalore Blue'.

Age-specific longevity and fecundity of two spotted spider mite, *T. urticae*: The increasing order of fecundity of mites on the four varieties (Tab. 3) are 'Thompson Seedless' > 'Gulabi' > 'Manjri Naveen' > 'Bangalore Blue' ($F = 76.6$; $P < 0.0001$). The mites laid 156.54 eggs in an oviposition period of 10.8 days in 'Thompson Seedless', 125.09 eggs in 9.6 d in 'Gulabi', 36.99 eggs in 7.4 d in 'Manjri Naveen' and 21.52 eggs in 4.6 d in 'Bangalore Blue'. There was significant difference in the intrinsic rate of increase (r_m) between the four varieties ($F = 68.16$; $P < 0.0001$). The values of r_m (Tab. 4) was found to be the highest in 'Thompson Seedless' (0.107) followed by 'Gulabi' (0.097), 'Manjri Naveen' (0.067) and the lowest in 'Bangalore Blue' (0.043). The difference in the net reproductive rate (R_0) among the four varieties exhibited the same pattern like r_m ($F = 87.59$; $P < 0.0001$). The value of R_o was found to be the highest in 'Thompson Seedless' (125.43) followed by 'Gulabi' (94.46), 'Manjri Naveen' (26.01) and the lowest in 'Bangalore Blue' (11.84). The mean generation time was found to be the shortest in 'Thompson Seedless' (19.73) followed by 'Manjri Naveen' (20.94), 'Gulabi' (21.68) and the longest in 'Bangalore Blue' (24.96). Significant difference in the doubling time of mites in the four varieties was noticed ($F = 43.85$; $P < 0.0001$). The shortest doubling time was found in 'Thompson Seedless' (2.84 days) followed by 'Gulabi' (3.32 d), 'Manjri Naveen' (4.42 d) and 'Bangalore Blue' (7.14 d). Similar trend of r_m and R_0 was noticed for the finite rate of increase (λ).

Table 3

Reproductive parameters of two spotted spider mite, *T. urticae* on different grape varieties

Varieties	Adult female longevity (d)	Total fecundity/ female	Pre oviposition (d)	Oviposition (d)	Post oviposition (d)
Thompson Seedless	8.36 ± 0.53a	156.54 ± 17.07a	1.0 ± 0.00a	10.8 ± 0.84a	0.6 ± 0.55a
Manjri Naveen	5.02 ± 0.39c	36.99 ± 6.30c	0.6 ± 0.55b	7.4 ± 0.89c	0.8 ± 0.84a
Gulabi	6.92 ± 1.32b	125.09 ± 28.08b	1.0 ± 0.00a	9.6 ± 1.14b	0.6 ± 0.55a
Bangalore Blue	2.51 ± 0.49d	21.52 ± 4.10c	0.0 ± 0.00c	4.6 ± 0.55b	0.4 ± 0.55a
F value	53.07	76.60	14.89	47.91	0.33
P value	0.0001	0.0001	0.0001	0.0001	0.8014

Means followed by same letters do not differ significantly by Tukey's HSD @ 0.05 %.

Table 4

Life table parameters of two spotted spider mite, *Tetranychus urticae* on selected varieties of grapevine

Varieties	Net Reproductive Rate, Ro	Intrinsic Rate of Increase, r_m	Mean Generation Time Tc (days)	Finite rate of increase (λ)	Doubling Time (days)
Thompson Seedless	125.43 ±12.66a	0.11 ±0.01a	19.80 ± 1.76b	1.28 ± 0.03a	2.84 ± 0.30c
Manjri Naveen	26.01 ± 3.93c	0.07 ± 0.00c	20.94 ± 1.27b	1.17 ± 0.01c	4.42 ± 0.20b
Gulabi	94.46 ± 22.13b	0.09 ± 0.01b	21.67 ± 1.69b	1.23 ± 0.02b	3.32 ± 0.20a
Bangalore Blue	11.84 ± 3.01c	0.04 ± 0.01d	24.95 ± 1.96a	1.11 ± 0.02d	7.14 ± 1.23c
F value	87.59	68.16	8.59	67.22	43.85
P value	< 0.0001	< 0.0001	0.0013	< 0.0001	< 0.0001

Means followed by same letters do not differ significantly by Tukey's HSD @ 0.05 %.

Discussion

The biology of two spotted spider mites was studied on four varieties 'Thompson Seedless', 'Manjri Naveen', 'Gulabi' and 'Bangalore Blue' revealed that the lifecycle consists of egg, larvae, protonymph, deutonymph and adult stages. The lifecycle of mites was found to be shortest on 'Thompson Seedless' followed by 'Manjri Naveen', 'Gulabi' and 'Bangalore Blue'. This is clear evidence that mites can complete several generations in a season on varieties favorable for its development causing heavy damage. The result can be used for the management of mites in other ways that short spraying intervals would be more efficient for mite control. Since two-spotted spider mite has a life cycle between 14-17 d, spraying interventions can be done in 1- or 2-week intervals to manage the overlapping populations of mites in the vineyards. Bhagat and Singh (1999) also observed that the developmental period (egg to adult) ranged from 13 to 20 d for *T. urticae* on eggplant.

The duration of egg and larval stages varied among the varieties, being shortest on 'Thompson Seedless' and 'Gulabi' followed by 'Bangalore Blue'. Kumar *et al.* 2013 reported similar finding that the larval and nymphal period of *T. urticae* ranged from 1 to 4 and 1 to 3 days respectively. Longevity of adults was found to be shortest in 'Bangalore Blue' indicating that the adult can cause damage for shorter periods comparatively. Fecundity was found to be relatively lowest in 'Bangalore Blue' compared to the rest of the varieties. The rate of survival of immature stages of mites was found to be comparatively lower in 'Bangalore Blue' compared to the rest of the chosen varieties. The survival rate of the active feeding stages *i e.,* protonymph, deutonymph and adult is an important factor for causing potential damage. The result of the present study implies that 'Bangalore Blue' is the least preferred variety for the growth and development of the two spotted spider mite, *T. urticae*.

The life table characteristics *viz.,* net reproductive rate, intrinsic rate of increase, finite rate of increase and mean generation time of mites were estimated on four selected varieties *viz.,* 'Thompson Seedless', 'Manjri Naveen', 'Gulabi' and 'Bangalore Blue' of grapevine. The two-spotted spider mites, *T. urticae* showed relatively better performance on 'Thompson Seedless' and least growth parameters on 'Bangalore blue'. The poor performance of mites on 'Bangalore Blue' may be attributed to the poor survival rate and fecundity. The reason for relatively lower fecundity and development of mites in 'Bangalore Blue' may be due to dense tomentous hairs on the ventral side of leaf blade. This finding is in conformity with the reports of Steinite and Ievinsh (2003) that hairy leaf cultivars of cotton confer resistance to red spider mites, compared to the glabrous varieties. This may be due to the reduced movement and physical activity on the leaves with dense hairs. Other probable reasons may be due to the presence of morphological features and alellochemicals present in the variety (Agrawal 2000, Pietrosiuk *et al.* 2003).

Intrinsic rate of increase (r_m) is a vital parameter to evaluate the growth potential of a population under specific climatic and food conditions, as it reflects the overall effects of temperature and food on pest development, reproduction and survival (Southwood and Handerson 2000). The highest r_m values in 'Thompson Seedless' might be due to the highest suitability of the variety for the development of mites and the lower r_m in 'Bangalore Blue' shows the non-suitability of the variety for mites development. The insect can establish in a shortest possible time span with greatest population on 'Thompson Seedless'. The net reproductive rate (R_0) is a key statistic that pertains to the reproductive capability of an animal relative to its reproductive capacity (Khanamania *et al.* 2013). There was significant difference in the R_o values of mites in the cultivars. The value of R_o was highest in 'Thompson Seedless' and least in 'Bangalore Blue'. The net reproductive rate of mites on 'Gulabi' and 'Manjri Naveen' was statistically on par. The value of intrinsic rate of increase relates to the suitability and unsuitability of the cultivar for the growth and development of the insect population (Najafabadi *et al.* 2012).

The use of moderately resistant varieties as a part of insect management strategy can enhance the biological and chemical tools of insect pest management. One of the ways to decrease the pest damage is to use varieties which show higher resistance to insect pests such as 'Bangalore Blue' in areas where mites and mealy bug incidences are high. 'Bangalore Blue' being a less suitable variety for mite population build up also demands less use of acaricides for management of mites. Valadão *et al.* 2012 reported that 'Niagara Rosada' (*V. labrusca*) to possess higher mortality, lower fertility and lower survival of two spotted spider mite, *T. urticae*. *V. labrusca* cultivars with comparatively better fitness parameters than *V. vinifera* was reported by Bertin *et al.* 2013. Gu and Pomper 2008 reported that physical characteristics of grapevine host plant leaves could determine Japanese beetle preference and cultivars showing an incidence of damage greater than 70 % were either French hybrid cultivars (*V. vinifera*), and those with less than 70 % damage were either American cultivars with a *V. labrusca* background. There is an increasing demand for organic viticulture where in tolerant variety like 'Bangalore Blue' could be further well exploited as a prominent cultivar under Indian conditions. 'Bangalore Blue' being a labrusca type, this variety can be further utilized in breeding programs of grapevine with greater degree of resistance to mite pests.

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