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SCREENING OF PUMMELO (*Citrus maxima* Merr.) GERMPLASM FOR RESISTANCE TO CITRUS LEAF MINER, *Phyllocnistis citrella* Stainton.

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ABSTRACT : Fourteen germplasm collections of pummelo (*Citrus maxima* Merr.) were screened for resistance to citrus leaf miner, *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillaridae) during 2005-07. The per cent leaf infestation and the number of active mines per leaf were considered to assess the performance of germplasm collections. There was a positive correlation between the per cent leaf infestation and the number of active mines per leaf. Based on these two parameters, infestation index was calculated which was used to classify the accessions into different resistance classes. None of the genotypes were resistant but four accessions *viz.*, 'Devanahalli Selection-1', 'IPK-1', 'Raichur Selection-7' and 'Tirupati Selection-2' were moderately resistant. Among the rest, eight collections were susceptible and two were highly susceptible. This study has shown the existence of variability among pummelo collections in their reaction to *P. citrella*.

Keywords : Citrus leaf miner, infestation index, *Phyllocnistis citrella*, pummelo, resistance

INTRODUCTION

The pummelo (*Citrus maxima* Merr.) is native to southeastern Asia and is the largest fruit of citrus group with numerous medicinal and nutritional values. However it remained an underutilized fruit with high potential for commercial cultivation. Like many other citrus species, pummelo is also vulnerable to a number of insect pests and the citrus leaf miner, *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillaridae), is the most serious of them. When the infestation is severe, leaf damage due to miner could exceed 80 per cent and there will be 30-40 per cent yield reduction in the following year (Shivankar *et al.*, 2002). Female moth lays minute spherical eggs along the leaf midrib. Incubation period lasts for 2-3 days and larval period for 10-15 days. The larvae, soon after hatching, mine into leaf and construct a silvery white, shining gallery. Infested leaves turn pale, curl up, become distorted and sometimes drop off. Pupation takes place inside the mines and normally lasts for 6-8 days. Successful control of leaf miner with chemicals is challenging, as larvae and pupae remain concealed under leaf epidermis. Various control methods have been proposed for the management of citrus leaf miner including cultural practices, chemical control, use of petroleum spray oils and biological control (Beattie *et al.*, 1995; Rae *et al.*, 1996; Shivankar *et al.*, 2002 and Jayanthi and Verghese, 2004). Although some of the chemicals were found to be effective, they could not provide long lasting relief as some eggs

and early instars were reported to escape and resulting in reinfestation within a week of insecticidal application (Boulahia *et al.*,1996). Besides, the indiscriminate and frequent use of synthetic chemicals is undesirable from the environment and food safety point of view. Though some of natural enemies are reported to exercise satisfactory control, lack of their availability for release restricts the applicability of biological control. Considering these limitations, it is worthwhile to explore the host plant resistance, as it is one of the most sustainable and safe components of integrated pest management strategy. There are reports on the existence of variability among different citrus groups and varieties in their susceptibility to citrus leaf miner (Singh *et al.*, 1988; Batra *et al.*, 1992 and Arora *et al.*, 2001) but the scope of host plant resistance in pummelo against *P. citrella* has not been studied. This paper reports the findings based on the field evaluation of pummelo germplasm collections for their reaction to the incidence of citrus leaf miner.

MATERIALS AND METHODS

Field evaluation of 14 germplasm collections of pummelo was carried out to assess their resistance or susceptibility against citrus leaf miner at Indian Institute of Horticultural Research, Bangalore during 2005-06 and 2006-07. The experimental field consisted of four to five year old trees of pummelo genotypes collected from different parts of the country. Observations on the number of total and infested leaves were recorded at fortnightly interval during January to March from ten randomly selected terminal shoots per tree covering four trees of each genotype. Among the infested leaves, ten leaves were randomly chosen to count the number of active mines (those containing live larvae or pupae) in each replication during new flush period. The intensity of attack was assessed in terms of per cent leaf damage due to miner and the mean number of active mines (those containing live larvae or pupae) per leaf. Based on these two parameters, the infestation index was calculated by using the following formula which was a slightly modified version of the one proposed by Arnaoudov and Kutinkova (2006) for apple aphid infestation.

$$\text{Infestation index} = \frac{\text{Per cent leaf infestation} \times \text{Mean number of active mines/leaf}}{100}$$

According to the value of infestation index, the accessions were categorized as resistant (infestation index 0.1-0.5), moderately resistant (0.6 to 1.0), susceptible (1.1 to 2.0) and highly susceptible (> 2.0). Correlation between the extent of leaf damage and the number of active mines was also assessed. Data on per cent values were subjected to angular transformation before analyzing through ANOVA for significance of differences at 5 per cent level of significance.

RESULTS AND DISCUSSION

Results (Table1) indicated that no accession was completely free from the leaf miner infestation. However there were significant variations among genotypes in their susceptibility to *P. citrella*. During 2005-06, the leaf infestation ranged from 15.67 per cent in 'Tirupati Selection-2' to 44.65 per cent in 'Midnapore Selection-2'. Besides 'Tirupati Selection-2', 'Raichur Selection-7' (16.47%), 'Devanahalli Selection-1' (18.18%) and 'IKP-1' (18.04%) were the least infested accessions. In the following year too, 'Tirupati Selection-2' (18.90%) followed by 'Raichur Selection-7' (20.70%) and 'IKP-1' suffered the least leaf damage due to leaf miner while 'Khanapure Selection-1' (44.90%) and both the 'Midnapore Selections 1' (42.40%) and 2 (40.70%) were the most susceptible accessions. There was a consistency in the genotype response to the pest in both the years. As per the pooled data of two years, the extent of leaf damage varied from 17.28 per cent in 'Tirupati Selection-2' to 43.44 per cent in 'Khanapur Selection-1'.

Table 1. Incidence of citrus leaf miner (*Phyllocnistis citrella*) on pummelo germplasm collections.

Genotype	Leaf damage (%)			Mean No. of active mines/leaf (b)	Infestation index (a x b/100)
	2005-06	2006-07	Pooled (a)		
Devanahalli Selection-1	18.18 (25.23)	21.20 (27.42)	19.69 (26.35)	4.50	0.89
Hyderabad Selection -1	32.08 (34.51)	31.18 (33.95)	31.59 (34.20)	3.45	1.09
IKP-1	16.04 (23.61)	23.00 (28.66)	19.52 (26.23)	2.86	0.56
IKP-2	32.48 (34.74)	35.73 (36.6)	34.09 (35.72)	3.70	1.26
Kalenahalli Selection	25.36 (30.23)	26.45 (30.92)	25.88 (30.56)	3.98	1.03
Kallar Selection -1	30.34 (33.40)	32.62 (34.82)	31.47 (34.10)	3.40	1.07
Khanapur Selection -1	41.88 (40.32)	44.94 (42.09)	43.44 (41.22)	2.80	1.21
Midnapore Selection -1	39.10 (38.70)	42.45 (40.63)	40.75 (39.65)	5.77	2.35
Midnapore Selection -2	44.65 (41.93)	40.72 (39.64)	42.67 (40.75)	6.29	2.68
Raichur Selection -7	16.47 (23.89)	20.73 (27.06)	18.58 (25.50)	3.69	0.68
Selection -1	26.56 (30.34)	29.30 (32.97)	27.93 (31.90)	4.43	1.24
Selection- 2	24.44 (29.60)	26.71 (31.05)	25.57 (30.35)	4.24	1.08
Tirupati Selection -1	32.09 (34.51)	35.38 (36.45)	33.69 (35.68)	5.95	2.00
Tirupati Selection -2	15..67 (23.26)	18.94 (25.77)	17.28 (24.56)	3.41	0.58
CD (*p=0.05*)	3.76	4.21	3.83	1.84	

Figures in parentheses are angular transformed values

Table 2. Classification of pummelo germplasm accessions according to their reaction to citrus leaf miner

Resistance/Susceptibility category	Genotypes
Resistant (infestation index 0.1-0.5)	——
Moderately Resistant (infestation index 0.6-1.0)	Devanahalli Selection-1, IKP-1, Raichur Selection -7, Tirupati Selection -2,
Susceptible (infestation index 1.1 – 2.0)	Hyderabad Selection -1, IKP-2, Kalenahalli Selection, Kallar Selection -1, Khanapur Selection -1, Tirupati Selection -1, Selection- 2, Selection -1
Highly Susceptible (infestation index >2.0)	Midnapore Selection -1, Midnapore Selection -2

The number of active mines per leaf among genotypes varied significantly and there was a significant positive correlation (r = 0.754) between the per cent leaf damage and the number of active mines per leaf indicating the preference of the pest to multiply on the varieties found susceptible. The mean number of mines was lowest (3.41) in 'Tirupati Selection-2' and highest (6.29) in 'Midnapore Selection-2'. The number of mines serves as a guiding factor while comparing the performance of genotypes or varieties which are on par with each other in the per cent leaf damage. In such cases, the variety with the lowest number of mines need to be scored favourably as the potential resistance source. In order to meet this need, both these factors were taken into account in the form of infestation index. As per the classification based on the infestation index, none of the genotypes was resistant but four collections *viz.*, 'Tirupati Selection-2', 'Raichur Selection-7', 'Devanahalli Selection-1' and 'IPK-1' were moderately resistant to leaf miner. Among the three collections which suffered above 40 per cent leaf damage, two *viz.*, 'Midnapore Selection -1' and 'Midnapore Selection -2 were graded as highly susceptible with infestation index exceeding 2, while 'Khanapur Selection -1', in spite of suffering on par leaf damage, was categorized as only susceptible owing to its lower number of active mines per leaf. The rest of the collections *viz.*, 'Hyderabad Selection -1', 'IKP-2', 'Kalenahalli Selection', 'Kallar Selection -1', 'Khanapur Selection -1', 'Tirupati Selection -1', 'Selection-2' and 'Selection -1' were graded as susceptible with infestation index ranging between 1.0 and 2.0.

The results obtained are well supported by the reports of earlier workers who recorded varied degrees of resistance among different citrus species and genotypes. Jacas *et al*. (1997) evaluated nine citrus related species and found *Murraya koenigii* and *Glycosmis pentaphylla*, which exhibited antibiotic effect on the first instar larvae as potential sources of resistance against *P. citrella*. Arora *et al*. (2001) screened about 60 cultivars of sweet oranges, lemons and lime and found 16 cultivars as least susceptible to citrus leaf miner. However Lei *et al.* (1997) could not locate any resistant genotype out of 36 genotypes screened but reported 11 genotypes as partially resistant. The ovipositional preference was considered to be an important factor in deciding the suitability of a species or variety to *P. citrella* (Goane *et al*., 2008). The findings of our study indicate the existence of variability among pummelo collections in their reaction to *P. citrella* and brought to light four accessions which are moderately resistant. This emphasizes the need for screening a large number of collections to identify resistance sources.

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