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Screening of okra cultivars/genotypes against two spotted red spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae)

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Abstract
The experiments were carried out to screen okra cultivars/genotypes against two spotted spider mites, *Tetranychus urticae* Koch in the field conditions at Instructional Farm, College of Agriculture, JAU, Junagadh, Gujarat during *Kharif* 2014 and 2015. Among the various okra cultivars/genotypes tested on the basis of mite incidence, categorization of cultivars/genotypes and yield of okra fruits, cultivar GAO-5 emerged out as highly resistant to *T. urticae* with lowest mite population and highest yield. Cultivars Arka anamika, GO-2, Arka abhay, GJO-3 and JOL-10-18 were found resistant, whereas JOL-5S-3, Pusa sawani and JOL-1 were susceptible. In contrast to this, Parbhani kranti was recorded as a highly susceptible cultivar.

Keywords: Biology, brinjal, leucinodes orbonalis, morphometry

Introduction
India is a major vegetable growing and consuming country in the world. Okra, *Abelmoschus esculentus* (L.) Moench is one of the most important vegetable crop which has its own importance with an account of its taste, flavour and nutritional values as human food. It is cultivated in an area of 5.01 lakh hectare with an annual production of 57.83 lakh tones an average yield of 11.5 t/ha during 2017-18 [1]. Incidence of insect pests is one of the prime factors in lower production of okra. Many insect pests infesting okra, among them, red spider mite, *Tetranychus urticae* Koch is an important and major biological constraint in okra production. Mites of the family Tetranychidae are undoubtedly among the many destructive pests of okra in many parts of the world. Nineteen insect pests and four mite pests have been reported on okra [2]. In order to prevent the infestation of the pests and to produce a quality crop, it is essential to manage the pest population with suitable measures. Chemical control is generally practiced by farmers for higher production, but its injudicious use has created many problems like resistance, resurgence of pests, pesticide residues, destruction of beneficial fauna and environmental pollution. Under such circumstances, use of resistant varieties in pest management are considered as prerequisite ecologically viable proposition which overcome the above mentioned problems. The resistant varieties of crops offer insect pest management at no additional cost. An insect resistant plant offer ideal prevention against insect damage, involved minimum cost of production and are eco-friendly. The use of resistant varieties is one of the most economical and effective methods of control. Keeping this in view, the present studies were undertaken to screen out the susceptibility or resistance of okra cultivars/genotypes against *T. urticae* during *Kharif*, 2013 and *Kharif*, 2014 at Instructional Farm, College of Agriculture, JAU, Junagadh, Gujarat.

Materials and Methods
The experiment was laid out in Randomized Block Design (RBD) with ten cultivars/genotypes as treatments (*viz.*, GJO-3, GO-2, GAO-5, Parbhani kranti, Arka anamika, Arka abhay, Pusa sawani, JOL-5S-3, JOL-1 and JOL-10-18) each replicated thrice. Each variety was sown in individual plot size of 4.0 X 5.0 m^2. The spacing between row to row and plant to plant was kept 60 cm and 30 cm, respectively. All the recommendations as per package of practices were followed to raise the crop.
For recording observations, five plants were randomly selected and tagged in each net plot area.

The mite population recorded from three (upper, middle and lower) leaves of 2 cm^2 area of same selected five plants. The observations were recorded at weekly interval starting from one week of germination till the removal of the crop. The marketable fruit yield was recorded during each picking from net plot area.

The different okra cultivars/genotypes were also categorized into highly resistant (HR), resistant (R), susceptible (S) and highly susceptible (HS) to *T. urticae*. For the purpose, mean value of individual varieties ($\bar{x}_i$) was compared with the mean value of all varieties ($\bar{x}$) and standard deviation (Sd) following the modified scale [3]. The retransformed data was used for computation of $\bar{x}$, $\bar{x}_i$ and Sd for the each parameter. The scale used for categorizing of different varieties was as under (Table-1).

Table 1: Categorization of cultivars/genotypes

S. No.	Category of resistance	Scale for resistance
1.	Highly resistant (HR)	$\bar{x}_i < \bar{x}$ - Sd
2.	Resistant (R)	$\bar{x}_i > (\bar{x}$ - Sd) < $\bar{x}$
3.	Susceptible (S)	$\bar{x}_i > \bar{x} < (\bar{x}$ + Sd)
4.	Highly susceptible (HS)	$\bar{x}_i > (\bar{x}$ + Sd) < ($\bar{x}$ + 2Sd)

Results and Discussions

The incidence of *T. urticae* was recorded from 3rd week after germination (WAG) till the removal of the crop. The data on incidence of red spider mite, *T. urticae* during year 2013 and 2014 are presented Table-2. Pooled over periods results of first year (2013) on incidence of red spider mite, *T. urticae* on different cultivars showed significant difference among the cultivars. Among the tested cultivars, significantly the lowest (3.17 mites/2 cm^2 leaf area) population of mite was found on GAO-5 followed by Arka anamika (5.05 mites/2 cm^2 leaf area). While, okra cultivars, GO-2, Arka abhay and GJO-3 were equally susceptible to mite incidence by recording 6.34 to 6.96 mites per 2 cm^2 leaf area but significantly less susceptible to remaining cultivars. Okra cultivars JOL-10-18 and JOL-5S-3 as well as Pusa sawani and JOL-1 were at par with each other but significantly differed in their descending orders. Among the evaluated cultivars, the highest (20.93 mites/2 cm^2 leaf area) population of mite was noticed in cultivar Parbhani kranti followed by JOL-1 and Pusa sawani.

More or less similar trend of susceptibility of okra cultivars against mite was observed in second year (2014) of experimentation too. The lowest (4.03 mites/2 cm^2 leaf area) incidence of mite was found in GAO-5 followed by Arka anamika (6.25 mites/2 cm^2 leaf area). Okra cultivars GO-2, Arka abhay and GJO-3 were found statistically equally susceptible to *T. urticae* by recording population between 7.59 and 8.55 mites per 2 cm^2 leaf area. However, these three cultivars differed significantly to remaining cultivars. The cultivars JOL-10-18 and JOL-5S-3 as well as Pusa sawani and JOL-1 were at par with each other in their descending orders. Among the tested cultivars against mites, the highest (25.34 mites/2 cm^2 leaf area) incidence of *T. urticae* was observed in Parbhani kranti followed by JOL-1.

Table 2: Incidence of red spider mite, *T. urticae* on different okra varieties/ genotypes during *kharif* 2013-14

Sr. No.	Varieties/ genotypes	No. of mites/ 2 cm^2 leaf area		
		2013	2014	Pooled over years
1.	GJO-3	2.64^c (6.96)	2.92^c (8.55)	2.78^c (7.73)
2.	GO-2	2.52^c (6.34)	2.75^c (7.59)	2.64^b (6.94)
3.	GAO-5	1.78^a (3.17)	2.01^a (4.03)	1.90^a (3.59)
4.	Parbhani kranti	4.58^f (20.93)	5.03^f (25.34)	4.81^f (23.09)
5.	Arka anamika	2.25^b (5.05)	2.50^b (6.25)	2.38^{ab} (5.64)
6.	Arka abhay	2.58^c (6.64)	2.87^c (8.21)	2.73^b (7.43)
7.	Pusa sawani	3.94^e (15.53)	4.35^e (18.91)	4.15^e (17.18)
8.	JOL-5S-3	3.25^d (10.56)	3.60^d (12.94)	3.43^d (11.73)
9.	JOL-1	4.02^e (16.17)	4.43^e (19.61)	4.23^{ef} (17.85)
10.	JOL-10-18	3.11^d (9.67)	3.45^d (11.87)	3.28^{cd} (10.76)
GM $\bar{x}$				11.70
Sd				7.89
S. Em. ± T		0.06	0.06	0.04
Y		0.06	0.07	0.07
T x Y		0.20	0.22	0.21
C.D. at 5% T		0.16	0.17	0.11
Y		0.18	0.19	0.19
T x Y		NS	NS	NS
C.V.%		11.45	11.19	11.32

1. Treatment means with the letter(s) in common are significant by DNMRT at 5% level of significance
2. Figures in parentheses are retransformed values; those outside are square root transformed values

Pooled over period and years results (Table-2) were computed for *kharif* 2013 and 2014 indicated that okra cultivar GAO-5 ranked first in registering the least (3.59 mites/2 cm^2 leaf area) number of mites. While, okra cultivars, Arka anamika, GO-2, Arka abhay and GJO-3 were equally susceptible to *T. urticae* by registering mite population between 5.64 and 7.73 mites per 2 cm^2 leaf area. Cultivars JOL-10-18 and JOL-5S-3 recorded 10.76 and 11.73 mites per 2 cm^2 leaf area, respectively and they were significantly less susceptible to remaining tested cultivars. Okra cultivar JOL-10-18 was equally susceptible as GJO-3. Among the tested cultivars, the highest (23.09 mites/2 cm^2 leaf area) mite incidence was noticed in Parbhani kranti followed by JOL-1 and Pusa sawani.

From the above results, it can be concluded that okra cultivar GJO-5 was found comparatively resistant to *T. urticae*, whereas Arka anamika, GO-2, Arka abhay and GJO-3 were moderately resistant to this pest. Okra cultivar GO-2 had the lowest number of mites as compared to other cultivars and also registered higher yield of marketable okra fruits [4]. In contrast to this, okra cultivars *viz.*, JOL-5S-3 and Pusa sawani were moderately susceptible, whereas JOL-1 and Parbhani kranti were susceptible to this pest. The okra cultivar, Parbhani kranti and Pusa sawani was the most susceptible to mite during *kharif* season [5]. Parbani kranti found as the most susceptible to mite [6-8]. While, Arka anamika was least susceptible while Pusa sawani was highly susceptible to mite attack [9]. Whereas, lowest number of mites on Arka anamika [10]. The maximum population of *T. urticae* (23.51 mites/leaf) was observed in Pusa sawani [11]. Thus, present findings were more or less confirmed with earlier workers.

The okra cultivars were further categorized in to four different categories on the basis of number of mites per 2 cm^2 leaf area by comparing the mean number of mites per individual cultivar ($\bar{x}_i$) with mean number of all cultivars ($\bar{x}$) and standard deviation (Sd) which is presented in Table-3.

Table 3: Categorization of different cultivars/genotypes of okra for their susceptibility to red spider mite, *T. urticae* during *Kharif* 2013-14

Category of resistance	Scale	Cultivars ($\bar{x}_i$)
Highly resistant (HR)	$\bar{X}_i < 3.81$	GAO-5 (3.59)
Resistant (R)	$\bar{X}_i > 3.81 < 11.70$	Arka anamika (5.64) GO-2 (6.94) Arka abhay (7.43) GJO-3 (7.73) JOL-10-18 (10.76)
Susceptible (S)	$\bar{X}_i > 11.70 < 19.59$	JOL-5S-3 (11.73) Pusa sawani (17.18) JOL-1 (17.85)
Highly susceptible (HS)	$\bar{X}_i > 19.59 < 27.48$	Parbhani kranti (23.09)
Population of mite/2 cm^2 leaf area: $\bar{x}$ = 11.70 and Sd = 7.89		
Mean number of mites per individual cultivar ($\bar{x}_i$) Mean number of all cultivars ($\bar{x}$) Standard deviation (Sd)		

Based on mite population, okra cultivar GJO-5 recorded 3.59 mites and falls under the category of highly resistant. Cultivars Arka anamika, GO-2, Arka abhay, GJO-3 and JOL-10-18 had mite population more than 3.81 but less than 11.70 hence, they were categorised under resistant. The cultivars JOL-5S-3, Pusa sawani and JOL-1 were registered under susceptible group, whereas cultivar Parbhani kranti categorised under highly susceptible group due to the mite population more than 19.59 per 2 cm^2 leaf area.

The okra fruit yield recorded during *kharif* 2013 and 2014 as well as pooled results are presented in Table-4 and illustrated graphically in Figure 1. During the year 2013, among screened okra cultivars, GAO-5 exhibited the highest (7580 kg/ha) fruit yield followed by Arka anamika, GO-2, Arka abhay, GJO-3 and JOL-10-18 which recorded fruit yield between 5436 and 6941 kg per ha during the first year of experimentation. The susceptible cultivar Parbhani kranti produced the lowest (2855 kg/ha) fruit yield followed by JOL-5S-3, Pusa sawani and JOL-1. However, in the second year of the experiment more or less similar trend was observed in yield performance of okra cultivars as recorded in the first year. GAO-5 registered the highest (7312 kg/ha) fruit yield followed by Arka anamika, GO-2, Arka abhay, GJO-3 and JOL-10-18 which produced 5289 to 6792 kg per ha okra fruits. The lowest (2681 kg/ha) okra fruit yield was registered from susceptible cultivar Parbhani kranti followed by JOL-5S-3, Pusa sawani and JOL-1.

Table 4: Fruit yield of different okra varieties/ genotypes during *kharif* season 2013-14

Sr. No.	Varieties/ genotypes	Okra yield (kg/ha)		
		2013	2014	Pooled over years
1.	GJO-3	5603^{cd}	5450^{cd}	5526^{cd}
2.	GO-2	6536^{abc}	6384^{abc}	$6460a^{bc}$
3.	GAO-5	7580^{a}	7312^{a}	7446^{a}
4.	Parbhani kranti	2855^{g}	2681^{g}	2768^{g}
5.	Arka anamika	6941^{ab}	6792^{ab}	6867^{ab}

6.	Arka abhay	6100^{bcd}	5966^{bcd}	6033^{bcd}
7.	Pusa sawani	4359^{f}	4255^{ef}	4307^{ef}
8.	JOL-5S-3	4507^{ef}	4375^{ef}	4441^{ef}
9.	JOL-1	3787^{fg}	3665^{fg}	3726^{fg}
10.	JOL-10-18	5436^{de}	5289^{de}	5363^{de}
S. Em. ± T		353.4	361.5	252.8
Y		-	-	113.0
T x Y		-	-	357.4
C.D. at 5% T		1050.0	1074.0	718.5
Y				321.3
T x Y		-	-	NS
C.V.%		11.4	12.0	11.7
Treatment means with the letter(s) in common are significant by DNMRT at 5% level of significance				

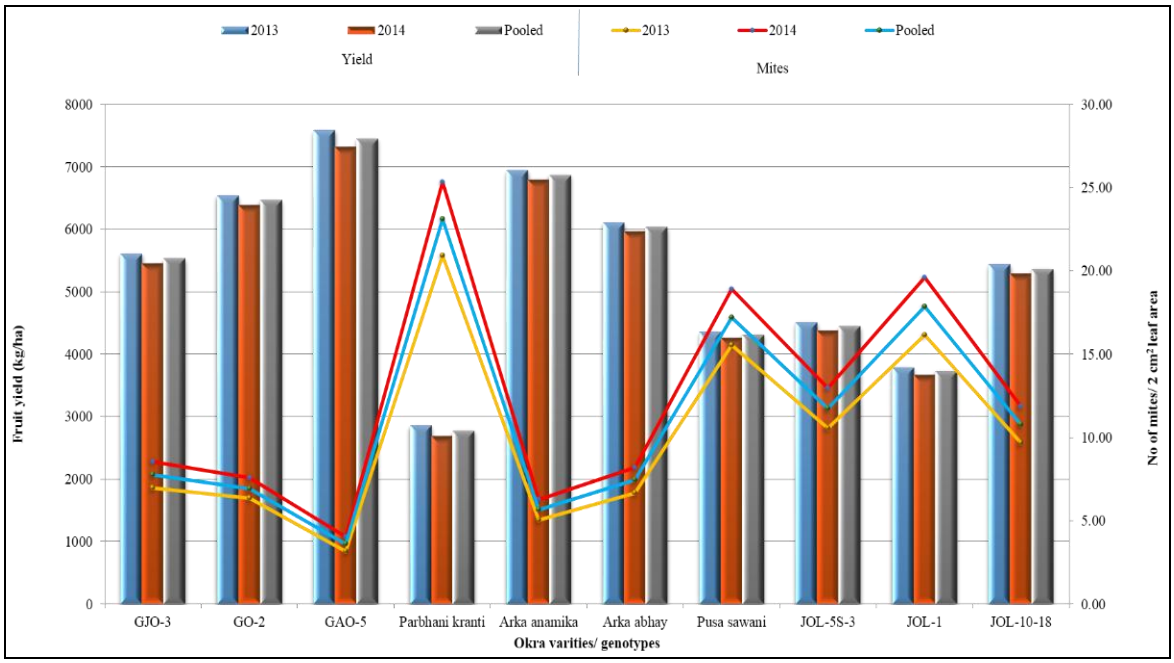

Fig 1: Incidence of red spider mite, *T. urticae* on different varieties/ genotypes and yield of okra during *Kharif*- 2013

Pooled over years results (Table-4) showed that the okra cultivar GAO-5 noticed significantly the highest (7446 kg/ha) fruit yield than all the tested cultivars. Cultivars, Arka anamika, GO-2, Arka abhay, GJO-3 and JOL-10-18 were produced fruit yield of okra between 5363 and 6867 kg per ha and found significantly higher to remaining cultivars. The statistically equal fruit yield was produced from JOL-5S-3 and Pusa sawani. Among the tested cultivars the lowest (2768 kg/ha) fruit yield was found from Parbhani kranti followed by JOL-1.

On the basis of mite incidence and yield of okra fruits, it can be extracted that cultivar GAO-5 emerged out as highly resistant to *T. urticae.* While, cultivars Arka anamika, GO-2, Arka abhay, GJO-3 and JOL-10-18 were found resistant, whereas JOL-5S-3, Pusa sawani and JOL-1 were susceptible. In contrast to this, Parbhani kranti was noticed as highly susceptible cultivars. Similarly the okra cultivar GO-2 had the lowest number of mites and also registered higher yield of marketable okra fruits as compared to other cultivars *i.e.* Parbhani kranti [4]. Parbhani kranti as most susceptible to mean population of 183.4 *T. urticae* [12]. Arka anamika categorized as resistant while, Pusa sawani was found comparatively susceptible to the mite [13]. Pusa sawani and Parbhani kranti as highly susceptible while, Arka anamika proved less susceptible. He also found lowest fruit yield in Parbhani kranti [8]. GO-2 as resistant and Arka anamika as moderate resistant among tested germplasms [14]. Okra cultivars GAO-5, Arka anamika and GO-2 were found moderately resistant. In contrast to this, Parbhani kranti was recorded as susceptible cultivars [15]. Thus, the present findings are more or less in agreement with the results reported by earlier workers.

Conclusion

On the basis of mite incidence, categorization and yield of okra fruits, cultivar GAO-5 emerged out as highly resistant to *T. urticae* with the lowest mite population and highest yield. Cultivars *viz.*, Arka anamika, GO-2, Arka abhay, GJO-3 and JOL-10-18 were found resistant, whereas JOL-5S-3, Pusa sawani and JOL-1 were susceptible to *T. urticae*. In contrast to this, Parbhani kranti was recorded as highly susceptible cultivar with the highest mite population and lowest fruit yield.

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