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Screening of muskmelon genotypes aganist melon fruit fly, *Zeugodacus cucurbitae* (Coquillett) under field conditions

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Abstract
Using of resistant varieties is one of the effective, ecofriendly components of IPM for fruit flies due to the difficulties associated with biological and chemical control methods. Twenty five muskmelon genotypes were screened under field conditions at College of Horticulture, Anatharajupeta during *rabi* 2017-18 and 2018-19 and were grouped into different categories based on % fruit infestation. Among the screened genotypes, five genotypes, IC 315330P2, IC 321378, NMMH-24, Suvarna, IC 321327 were grouped under 'Resistant' category; eleven genotypes, Sharbath-e-nara, Patasha, IC 321333P2, IC 321323, Papayee-3, IC 321376, IC 321328, IC 321368, IC 321376, Papayee-sel, Sirangi were grouped under ' Moderately Resistant' category; Eight genotypes, Trisha-2, Alpur orange, NCSL, Allanagaram, IC 321343, KSP 1060, Amul-9, Sharbath were grouped under 'Suceptible' category and the only genotype grouped under 'Highly Susceptible' category was Papasa. Further it can be concluded, that the resistant genotypes identified through this study can be made use of as sources of resistance in breeding programme for development of fruit fly resistant varieties of muskmelon.

Keywords: Muskmelon, fruit flies, genotypes, screening

Introduction
Muskmelon is a great source of beta-carotene, folic acid, potassium, vitamin A and vitamin C. The potassium content of the fruits helps to control blood pressure and prevents hypertension and also reduces the risk of heart diseases. Muskmelon (*Cucumis melo* L.) is an important horticultural crop in India and worldwide playing an important role in international trade. India is the first largest producer of melons among the SAARC countries and second among the BRICS countries [1]. In India, muskmelon is grown in 57 thousand hectares with a production of 1277 thousand tones with a productivity of 23.6 tonnes/ha [1]. In Andhra Pradesh muskmelon is grown in an area of 9.9 thousand hectares with a production of 314.39 thousand MT and AP ranks second in both muskmelon area and production in India [6].
Among the various pests infesting muskmelon crop, cucurbit fruit fly (*Zeugodacus cucurbitae* Coquillett) is the major one. The female flies prefer to oviposit on soft tender, physiologically ripen fruit tissues puncturing with it's ovipositor and inserting eggs 2-3mm deep in the soft pulp. Watery fluid oozes out from the punctures, which later transform into dry resinous deposit. As the eggs hatches out the developing maggots feed on the pulp internally. The affected fruits get distorted and drop off prematurely, losing market value. Thus it becomes difficult to manage these flies with insecticides. Cucurbits being the major hosts for these fruit flies, the extent of loss ranges between 30-100% based on the season and the existing climatic conditions [2]. Krishna Kumar *et al*. (2006) reported fruit fly infestation as 28.55% in watermelon, 77.03% in bitter gourd, 75.65% in ridge gourd, 73.83% in cucumber and 63.31% in pickling cucumber and 100% damage was also reported in cucumber [9]. There is an urgent need to develop alternative management tools against fruit flies management. One such ecofriendly management tool is using of resistant varieties. Hence an investigative study was undertaken to screen 25 muskmelon genotypes against fruit flies under field conditions.

Materials and Methods
Screening of muskmelon genotypes was carried out during *rabi* 2017-18 and 2018-19 with a twenty five varieties/genotypes (24-genotypes, 1-variety) of muskmelon, *viz*., IC- 321333P2, KSP-1060, Papayee selection, IC-321343, Patasha, Alpur orange, Allanagaram, Papayee-3, Papasa, IC-315330P2, IC- 321333P2, IC-321323, IC-321328, IC-321376, IC-321378, IC-321327, Amul-9, NMMH-24, NCSL, Sirangi, Trisha-2, Suvarna, Sharbath, Sharbath-enara,

and Arka Jeet were sown at the experimental farm of College of Horticulture, Anantharajupeta (13.98°'N,79.40°'E). The crop was sown in January i.e. on 4/1/2018 and on 16/1/2019 with three replicates (blocks) for each genotype following a randomized block design. The area of each bed was 5 m × 2 m and the plant-to-plant distance of 50 cm was maintained with a drip irrigation system. Seeds of the muskmelon crop were soaked in water for 2 hrs before sowing to soften their seed coat. All the recommended agronomic practices (weeding, fertilization, hoeing etc.) were performed equally in each experimental bed. Three pickings were done for the entire growing season of muskmelon fruits.

Five fruits were randomly selected from each picking from each experimental bed; a total of 15 fruits were taken from each picking of each genotype and were brought to the laboratory for microscopic examination for fruit infestation. The infested fruits were sorted out and the per cent fruit infestation was calculated. These fruits were further examined and counted the number of larvae in each infested fruit. The cumulative percent fruit infestation was worked out on the basis of total number of fruits from all the picking as given below.

$$\text{Percent fruit infestation} = \frac{\text{Total no. ofinfestedfruits}}{\text{Total no. of fruits observed}} \text{X } 100$$

The genotypes were categorized by following the rating system given by Nath (1966) for fruit infestation.

Table 1: Susceptibility rating scale of the genotypes on the basis of percent fruit damage

Scale	Fruit damage (%)	Rating
1	No damage	Immune
2	1 – 10	Highly resistant
3	11 – 20	Resistant
4	21 – 50	Moderately resistant
5	51 – 75	Susceptible

Statistical analyses

Transformations (angular & square root transformed value) were used to achieve normality in the data before analysis. The data on percentage fruit infestation were analyzed through one-way ANOVA using SPSS 16 software at the 95% significance level. To determine the role of a genotype towards susceptibility in percentage within the test material, host plant susceptibility indices (HPSI) were calculated by using the following formula.

% HPSI = 100- (B-A)/B X 100

Where, A is larval population per fruit or % fruit infestation in individual genotype and B is larval population per fruit or % fruit infestation in all genotypes of muskmelon on an average.

Results and Discussion

Fruit infestation

The data from the table-1 (fig.1) reveals that during *rabi* 2017-18, the per cent fruit infestation and larval density/ fruit ranged from 15.57% - 81.98%, 3.97 – 25.24 respectively among the tested genotypes. Highest fruit infestation (81.89%) was observed in 'Papasa' and lowest recorded in IC 321378 (15.57%) and IC 315330P2 (16.84%) genotypes. However, larval density/ fruit were highest in Sharbath (25.24) and lowest in IC 321378 (3.97).

During *rabi* 2018-19 (Table 2 and fig.2), % fruit infestation and larval density/ fruit ranged from 12.64% - 83.11%, 3.47 – 23.20 respectively among the tested genotypes. Highest fruit infestation was recorded in Papasa (83.11%) and it was lowest in IC 315330P2 (12.64%). Similarly highest larval density/fruit was recorded in genotypes Allanagaram (23.20) and Sharbath (22.47) and lowest in genotype Suvarna (3.47) which was followed by the genotypes Sharbath enara (4.48) and IC 321327 (4.73) respectively.

The pooled data from the table-3 (fig.3) indicated that both % fruit infestation and larval density/fruit are showing wide variation among the different test varieties/genotypes, ranging from 14.74%-82.54% and 4.61-23.96 respectively and the two parameters are found to be significantly lower in resistant lines than in the susceptible ones. The highest % fruit infestation was recorded inPapasa (82.54%) followed by Sharbath (74.54%), KSP 1060 and Amul-9 (70.47%). The lowest % fruit infestation was recorded in genotypes IC 315330P2 (14.74%), IC 321378 (15.44%) followed by NMMH-24 (17.79%) and Suvarna (18.56%). Overall observation revealed that the genotypes in which fruit infestation is either highest or lowest are not necessarily showing the same trend in their larval density/ fruit too, as the matured maggots fell down into soil for pupation. The other reason might be that some fruit parameters (morphological/chemical) might be influencing their survival within the fruit.

Resistance categorization of the Screened muskmelon varieties/genotypes against fruit flies

The 25 screened genotypes were categorized into six categories (Table-2, Fig.-4) *viz*., Immune (no damage), Highly resistant (1-10%), Resistant (11-20%), Moderately resistant (21-50%), Susceptible (51-75%), Highly susceptible (>75%) based on their % fruit infestation following the rating system given by Nath (1966) for fruit infestation. Among all the screened genotypes, five genotypes *viz*., IC 315330P2, IC 321378, NMMH-24, Suvarna, IC 321327 are grouped under 'Resistant' category; eleven genotypes, Sharbath enara, Patasha, IC 321333P2, IC 321323, Papayee-3, IC 321376, IC 321328, IC 321368, IC 321376, Papayee-sel, Sirangi were grouped under ' Moderately Resistant' category; eight genotypes, Trisha-2, Alpur orange, NCSL, Allanagaram, IC 321343, KSP 1060, Amul-9, Sharbath were grouped under 'Suceptible' category and the only genotype which was grouped under 'Highly Susceptible' category was 'Papasa'. It was also observed from the above results that none of the tested genotypes fell under the categories of 'Highly Resistant' and 'Immune'. From the above results it could be concluded that the resistant cultures (IC 315330P2, IC 321378, NMMH-24, Suvarna, IC 321327) are recorded with lowest per cent fruit infestation and larval density and higher in susceptible genotypes of muskmelon. Similar findings were reported in muskmelon [5], in cucumber [3] and in watermelon [8].

Host plant susceptibility indices (HPSI %) of the screened genotypes

To determine the trend of the tested cultures towards the susceptibility, Host Plant Susceptibility Indices (HPSI %) based on both % fruit infestation and larval density/fruit were calculated (Table-2)

During *rabi* 2017-18 among different test genotypes, 'Papasa' showed maximum HPSI value of 188.51% based on % fruit infestation. Similar trend was observed during 2018-19 (190.87%) and pooled analysis (189.66%) results and was categorized as highly susceptible genotype. However, the resistant genotype IC 315330P2 showed minimum HPSI values during *rabi* 2017-18, 2018-19 and pooled of 2017-19 i.e. 37.81%, 29.03%, 33.47% respectively. The genotype, Sharbath showed high HPSI % values based on larval density/fruit during *rabi* 2017-18, 2018-19 and pooled of 2017-19 i.e. 177.21%, 191.43%, 183.60% respectively and was categorized as 'highly susceptible' genotype. The genotype Suvarna showed lowest HPSI % based on larval density/fruit during *rabi* 2017-18, 2018-19 and pooled of 2017-19 i.e. 40%, 29.53%, 35.29% respectively and was categorized as resistant genotype. These results are in coordination with the results of Shravan *et al*., (2016), who have reported lower values of HPSI % based on fruit infestation on resistant varieties/genotypes of watermelon. The authors opined that the genotypes Suvarna, IC-321327, IC-315330P2, IC-321378 and NMMH-24 with very low HPSI % values could be made use of as markers for the development of fruit fly resistant varieties of muskmelon.

Table 1: Evaluation of fruit fly resistance in various muskmelon genotypes and their

S. No.	Variety	Mean% fruit infestation			Larval density/Fruit			Category^{x}
		rabi 2017-18	*rabi* 2018-19	Pooled (2017-19)	*rabi* 2017-18	*rabi* 2018-19	Pooled (2017-19)	
1	Sharbat-e-nara	24.19^{i} (29.44)	26.01^{l} (30.65)	25.10^{l} (30.05)	7.01^{nop}	4.48^{l}	5.74^{n}	MR
2	Sirangi	44.50^{ef} (41.71)	52.79^{f} (46.60)	48.65^{g} (44.22)	10.37^{k}	8.5 7^{i}	9.47^{jk}	MR
3	KSP 1060	64.56^{c} (53.48)	76.59^{bc} (61.08)	70.58^{c} (57.16)	17.6^{ef}	20.79^{b}	19.20^{c}	S
4	IC-321323	42.58^{efg} (40.72)	26.67^{kl} (31.09)	34.63^{j} (36.03)	23.73^{b}	6.91^{j}	15.32^{e}	MR
5	Arka Jeet	47.06^{e} (43.31)	39.61^{h} (39.00)	43.34^{h} (41.17)	21.70^{c}	6.00 ^{jk}	13.85^{fg}	MR
6	Amul- 9	67.07^{bc} (55.01)	73.87^{c} (59.29)	70.47^{c} (57.11)	19.50^{d}	16.41^{e}	17.96^{d}	S
7	IC-321327	20.64^{ij} (27.00)	18.71^{m} (25.58)	19.67^{m} (26.30)	7.25^{mn}	4.73^{l}	5.99^{n}	R
8	IC -321343	69.21^{bc} (56.33)	67.74^{d} (55.40)	68.48^{c} (55.86)	12.43^{j}	15.64^{ef}	14.04^{f}	S
9	Alpur orange	55.35^{d} (48.07)	63.21^{e} (52.67)	59.28^{e} (50.35)	8.33^{lm}	12.14^{g}	10.24^{ij}	S
10	Suvarna	19.68^{ijk} (26.32)	17.45^{mn} (24.66)	18.56^{m} (25.50)	5.7^{q}	3.47^{m}	4.61^{op}	R
11	Papasa	81.98^{a} (64.88)	83.11^{a} (65.76)	82.54^{a} (65.30)	25.24^{a}	18.25^{d}	21.75^{b}	HS
12	Trisha-2	54.82^{d} (47.77)	51.73^{f} (45.99)	53.27^{f} (46.88)	17.33^{fg}	6.00 ^{jk}	11.67^{h}	S
13	IC-321376	42.60^{efg} (40.74)	33.15^{i} (35.14)	37.88^{ij} (37.97)	15.14^{hi}	11.13^{h}	13.14^{g}	MR
14	IC-315330 P2	16.84^{jk} (24.21)	12.64^{q} (20.75)	14.74^{op} (22.54)	9.47^{kl}	12.53^{g}	11.00^{hi}	R
15	IC-321333 P2	32.08^{h} (34.48)	29.25^{jk} (32.73)	30.66^{k} (33.61)	11.85^{j}	5.77^{k}	8.81^{kl}	MR
16	Papayee-sel	37.37^{gh} (37.68)	45.13^{g} (42.20)	41.25^{hi} (39.96)	16.23^{gh}	6.23^{jk}	11.23^{h}	MR
17	Papayee 3	42.01^{efg} (40.40)	31.21^{ij} (33.95)	36.61^{j} (37.22)	9.23^{kl}	6.93^{j}	8.08^{l}	MR
18	NCSL	67.37^{bc} (55.20)	61.24^{e} (51.50)	64.31^{d} (53.32)	14.17^{i}	12.71^{g}	13.44^{fg}	S
19	IC 321378	15.57^{k} (23.20)	15.30^{nop} (23.00)	15.44^{nop} (23.10)	3.97^{r}	15.17^{f}	9.57^{jk}	R
20	IC 321328	43.84^{efg} (41.46)	29.02^{jk} (32.58)	36.43^{j} (37.43)	16.19^{gh}	19.32^{c}	17.75^{d}	MR
21	Patasha	23.26^{i} (28.81)	36.97^{h} (37.43)	30.12^{k} (33.26)	5.82^{i}	8.13^{i}	6.98^{m}	MR
22	Sharbath	71.56^{b} (57.78)	77.51^{b} (61.83)	74.54^{b} (59.74)	25.45^{a}	22.47^{a}	23.96^{a}	S
23	NMMH-24	21.72^{ij} (27.76)	13.86^{opq} (21.79)	17.79^{mn} (24.91)	16.80^{h}	10.97^{h}	13.88^{fg}	R
24	Allanagaram	65.14^{c} (53.83)	70.18^{d} (56.91)	67.66^{b} (55.35)	19.58^{d}	23.20^{a}	21.39^{b}	S
25	IC 321368	40.64^{fg} (39.60)	35.67^{h} (36.66)	38.15^{ij} (38.14)	18.81^{de}	15.43^{f}	17.12^{d}	MR
	SE(m)	1.303	0.710	0.796	0.427	0.336	0.307	
	CD(*P*=0.05)	3.708	2.022	2.265	1.218	0.956	1.165	

xR-resistant, MR- moderately resistant, S- susceptible, HS- highly susceptible
values in the paranthesis are arc sin transformed values;
within each category, values followed by common letter do not differ significantly using DMRT

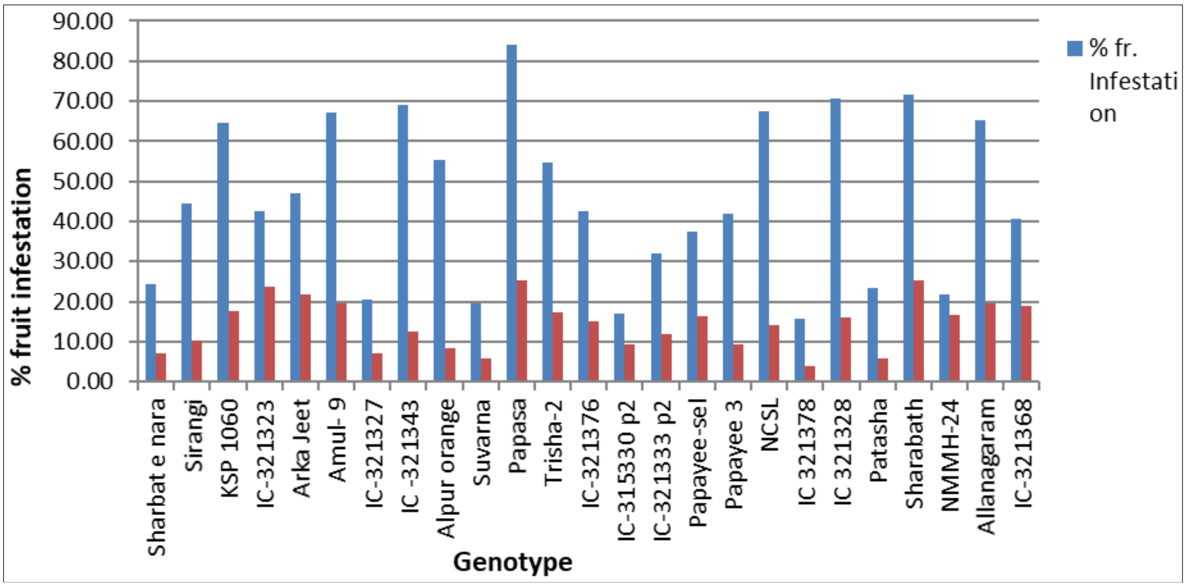

Fig 1: Fruit fly infestation recorded in different muskmelon varieties/genotypes (*rabi* 2017-18)

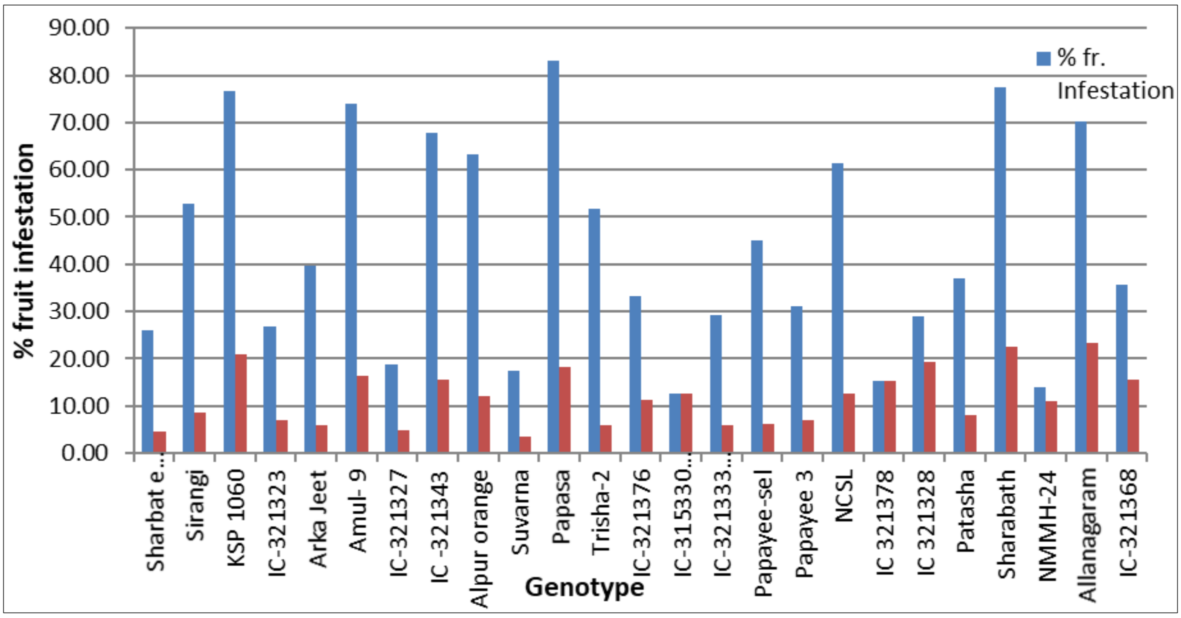

Fig 2: Fruit fly infestation recorded in different muskmelon varieties/genotypes (*rabi* 2018-19)

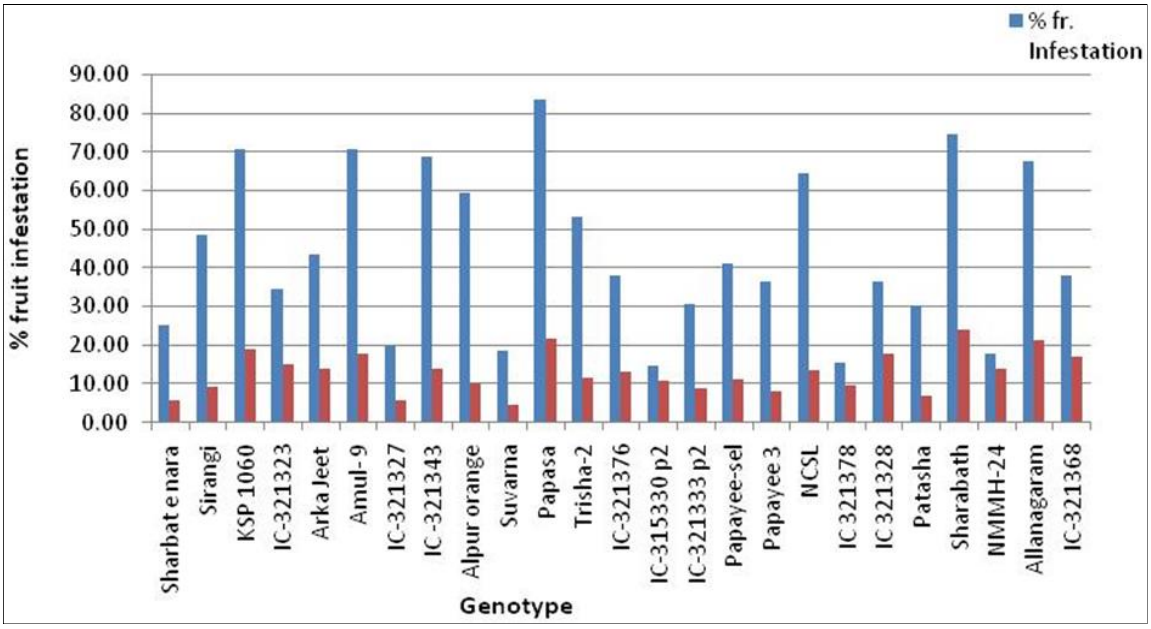

Fig 3: Fruit fly infestation recorded in different muskmelon varieties/genotypes (Pooled)

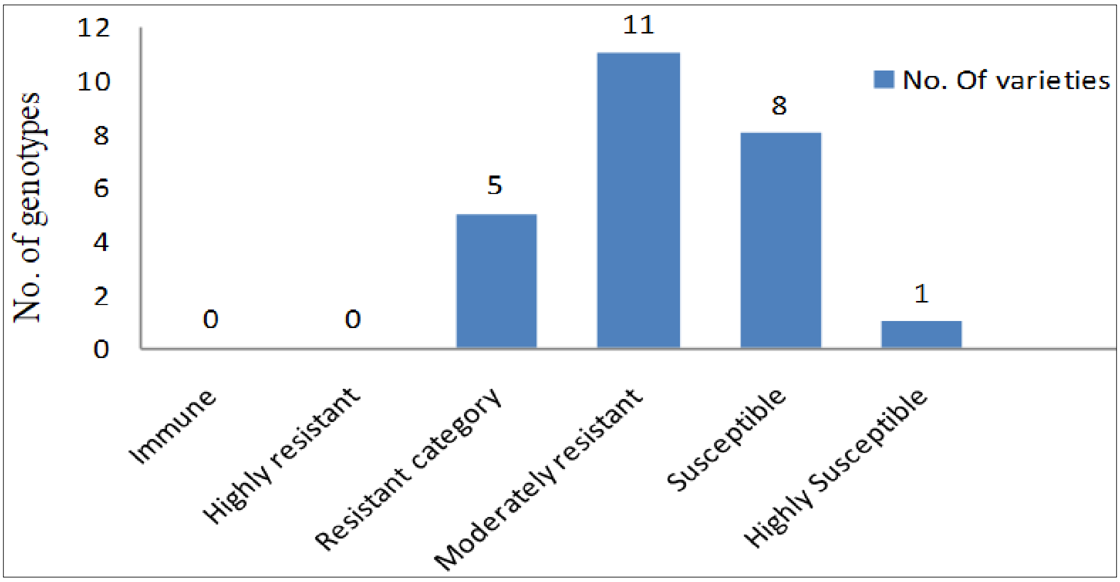

Fig 4: Resistant categorization of muskmelon genotypes based on rating scale given by Nath (1966)

Table 2: Host plant susceptibility indices (HPSI %) for fruit fly on muskmelon genotypes

S. No.	Variety	HPSI based on larval population (%)			HPSI based on fruit infestation (%)			Resistance Category
		Rabi (2017-18)	*Rabi* (2018-19)	Pooled (2017-19)	*Rabi* (2017-18)	*Rabi* (2018-19)	Pooled (2017-19)	
1	Sharbat enara	48.82	38.13	44.01	54.30	59.75	56.98	MR
2	Sirangi	72.19	72.97	72.54	99.90	121.25	110.44	MR
3	KSP 1060	122.54	177.12	147.09	144.92	175.91	160.22	S
4	IC-321323	165.27	58.83	117.39	95.57	61.26	78.60	MR
5	Arka Jeet	151.11	51.11	106.13	105.64	90.97	98.38	MR
6	Amul- 9	135.82	139.81	137.61	150.54	169.67	159.98	S
7	IC-321327	50.46	40.26	45.87	46.33	42.96	44.66	R
8	IC -321343	86.58	133.22	107.56	155.35	155.59	155.45	S
9	Alpur orange	58.03	103.41	78.44	124.25	145.18	134.58	S
10	Suvarna	40.00	29.53	35.29	44.18	40.07	42.14	R
11	Papasa	175.77	155.45	166.63	188.51	190.87	189.66	HS
12	Trisha-2	120.71	51.11	89.40	123.05	118.80	120.93	S
13	IC-321376	105.45	94.83	100.68	95.62	76.14	85.99	MR
14	IC-315330 P2	65.92	106.76	84.29	37.81	29.03	33.47	R
15	IC-321333 P2	82.54	49.12	67.51	72.00	67.18	69.61	MR
16	Papayee-sel	113.05	53.09	86.08	83.89	103.66	93.65	MR
17	Papayee 3	64.30	59.06	61.94	94.29	71.67	83.10	MR
18	NCSL	98.68	108.29	103.00	151.23	140.66	145.99	S
19	IC 321378	27.62	129.22	73.32	34.96	35.15	35.05	R
20	IC 321328	112.72	164.54	136.03	98.41	66.64	82.70	MR
21	Patasha	40.53	69.28	53.46	52.21	84.91	68.37	MR
22	Sharbath	177.21	191.43	183.60	160.63	178.02	169.21	S
23	NMMH-24	116.99	93.41	106.39	48.75	31.83	40.39	R
24	Allanagaram	136.33	197.64	163.91	146.22	161.18	153.59	S
25	IC 321368	130.99	131.46	131.20	91.22	81.92	86.61	MR

Conclusion

From the present study it can be concluded that Among the 25 muskmelon genotypes screened, five genotypes *viz.*, IC 315330P2, IC 321378, NMMH-24, Suvarna, IC 321327 are grouped under 'Resistant' category; eleven genotypes *viz.*, Sharbath-e-nara, Patasha, IC 321333P2, IC 321323, Papayee-3, IC 321376, IC 321328, IC 321368, IC 321376, Papayee-sel, Sirangi were grouped under ' Moderately Resistant' category; Eight genotypes *viz.*, Trisha-2, Alpur orange, NCSL, Allanagaram, IC 321343, KSP 1060, Amul-9, Sharbath were grouped under 'Suceptible' category and the only genotype which was grouped under 'Highly Susceptible' category was 'Papasa'. It was also observed from the above results that none of the tested genotypes fell under the categories of 'Highly Resistant' and 'Immune'. The five genotypes categorized under resistant category *viz.*, Suvarna, IC-321327, IC-315330P2, IC-321378 and NMMH-24 with very low HPSI % values could be further used as markers or sources of resistance in breeding programme for development of fruit fly resistant varieties of muskmelon.

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