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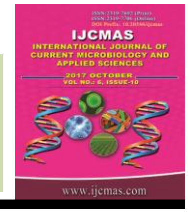

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Physico-Chemical Characters of Pumpkin (*Cucurbita moschata* Duch.) Ex Poir Genotype against the Melon Fly (*Bactrocera cucurbitae*) Reveals Resistance Traits in the Terai Region of West Bengal, India

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A B S T R A C T

Host plant resistance is an important component for management of the melon fruit fly, *Bactrocera cucurbitae* (Coquillett), owing to difficulties associated with its chemical and biological control. Twenty pumpkin cultivars collected from different sources from all over India have been evaluated against the infestation of melon fly *Bactrocera cucurbitae* (Coq.) under terai agro-ecological conditions of West Bengal. The degree of response varies among the cultivars against melon fly infestation. Intensity of infestation significantly varied from 50 % to 100 % among the test cultivars. Maximum infestation was recorded on cultivar V1 followed by V13 and V19. Minimum percent fruit infestation was observed in cultivars V4, followed by V11 and V5. The variation in melon fly infestation among the cultivars might be due to these allele chemical parameters of the fruit. Total sugar and reducing sugar, were lowest in resistant and highest in susceptible varieties whereas phenol content was highest in resistant and lowest in susceptible varieties. Total sugar content of fruit had a significant positive correlation (*P*=0.01), whereas Phenol contents had significant negative correlations with the percent fruit infestation

Introduction

Pumpkin (*Cucurbita moschata* var Duch. Ex Poir.) is one of the most important cucurbitaceous vegetable crops grown worldwide. Young leaves, flowers, immature and mature fruits of pumpkin are used as vegetable. This cucurbitaceous vegetable suffers severe insect-pest attack due to favourable conditions available for their multiplication and development. The fruit fly, *Bactrocera cucurbitae* (Coq.) (Diptera: Tephritidae) attacks fruits of the crop and is one of the most important biotic limiting factors. The extent of losses caused by the pest varies from 30-100% depending on cucurbit species and season (Waterhouse, 1993; Dhillon *et al.*, 2005a). Effective management of this dreaded pest is difficult due to its concealed feeding habit and typical life history. Efforts in fruit fly management were focused mainly on mature adult including bagging of fruits, field sanitation, bait traps, cuelure and sterile insect technique (SIT) (Hendrichs *et al.*, 2002), spray of protein baits with toxicants, growing fruit fly-resistant genotypes, augmentative releases of biological control agents, and soft insecticides. Conventional insecticides do not work well against the pest, rather, excessive use of pesticides cause development of resistance, resurgence, hazards to non-target organism and environmental pollution. In this perspective, host plant resistance (HPR) is one of the most important and promising aspects of pest management. Plants are generally exposed to a variety of biotic and abiotic factors that may alter their genotypic or phenotypic properties resulting in different mechanisms of resistance which enable plants to avoid, tolerate or recover from the effects of pest attacks (Gogi *et al.*, 2010b; Pedigo 1996; Sarfraz *et al.*, 2006). Such mechanisms of plant resistance have been effectively used against insect pests in many field and horticultural crops (Dhillon *et al.*, 2005b; Gogi *et al.*, 2010a; Kogan 1982; Sarfraz *et al.*, 2007). Mechanisms of resistance in plants are either constitutive or induced (Karban and Agrawal 2002; Painter 1951; Traw and Dawson 2002) and are grouped into three main categories: antixenosis, antibiosis and tolerance (Painter 1951).

Plants responsible for antibiosis resistance may cause reduced insect survival, prolonged developmental time, decreased size and reduced fitness of new generation adults (Gogi *et al.*, 2010b; Painter 1951; Sarfraz *et al.*, 2006, 2007). However, the indigenous cultivars have their innate heritable chemico-physical features to resist the infestation caused by the melon fruit fly. Unfortunately, information regarding the morphological factors such as skin toughness of fruit, skin thickness of fruit (Dhillon *et al.*, 2005b) and chemical factors such as in moisture level; ascorbic acid, reducing sugar, non-reducing sugar and total sugars, nitrogen, protein, phosphorus and potassium contents (Tewatia *et al.*, 1998) etc. responsible for this variation in different levels of infestations is vital for initiating crop improvement program to develop resistant lines. In the present study an initiative was undertaken to find out the impact of different physical and morphological traits of pumpkin fruits on the extent of infestation and field evaluation of pumpkin cultivars against the infestation of melon fruitfly.

Materials and Methods

Plant materials

The study was conducted at the Instructional Farm, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India (26 19’N latitude and 89 23’E longitude and an altitude of 43 MSL). Twenty varieties of Pumpkin including local accessions, open pollinated, hybrids were taken for study. The varieties taken for the study were as follows:

V1: Pumpkin collection, Eluru, Andhra Pradesh

V2: Baidyabati Kumra, KrishiMangal Vegetable Seeds, Kolkata

V3: Pumpkin collection, Pantnagar-2, Uttarakhand

V4: Baidyabati, Debgiri seed, Kolkata

V5: Pumpkin collection, Pasighat-1, Arunachal Pradesh

V6: Pumpkin collection, Pundibari Local-1, West Bengal

V7: Pumpkin collection, Pantnagar-1, Uttarakhand

V8: Pumpkin collection, Pundibari Long Variety, West Bengal

V9: Arka Suryamukhi, IIHR, Bangalore

V10: Pumpkin collection, Phek, Nagaland

V11: Pumpkin collection, Gagan Sardar Para-2, Tripura

V12: Pumpkin collection, Trivendrum, Kerala

V13: Pumpkin collection, Gagan Sardar Para-1, Tripura

V14: Pumpkin collection, Pasighat-2, Arunachal Pradesh

V15: Pumpkin collection, Komatapalli, Andhra Pradesh

V16: Pumpkin collection, Pundibari Local-2, West Bengal

V17: Pumpkin collection, Ambalavayal, Kerala

V18: Pumpkin collection, Pundibari Local-3, West Bengal

V19: Barahmasi, Varanasi, Uttar Pradesh

V20: Pumpkin collection, Pundibari Local-4, West Bengal

The test materials were planted on raised beds of 6m x 3m with a plant-to-plant spacing of 3m and row to row distance at 3m in December (winter season) of 2014 and February (summer season) of 2015. The experiment was replicated thrice arranged by following randomized block design (RBD). In each bed five plants were tagged randomly for recording observation. The winter season crop fruited in April-May and the summer season crop during June-July.

Recommended agronomic practices were adopted to raise the crop except chemical control of insect pests. Marketable sized fruits were picked at three days interval and brought to the laboratory for recording observation regarding physical characteristics and percent fruit infestation. The infested fruits were counted and the percent fruit infestation was calculated both in number and weight basis % fruit infestation was determined as follows:

$$\% \text{ fruit infestation} = \frac{\text{No. of fruit infested}}{\text{Total number of fruit observed}} \times 100$$

The genotypes were grouped by following the rating system, given by Nath (1966) for the fruit damage as immune (no damage), highly resistant (1-10%), resistant (11-20%), moderately resistant (21-50%), susceptible (51-75%) and highly susceptible (76-100%). The infested fruits were cut open to count the number of maggots of melon fly fruit.

Biochemical fruit traits

Biochemical fruit traits of different pumpkin varieties/ genotypes were studied. Three fresh fruits of each genotype were picked from the field randomly at three different stages i.e Early stage (0-10 DAS), Pre-maturity stage (20-25 DAS), Maturity stage (35-40 DAS) and brought to the Biochemistry Laboratory of UBKV, Pundibari, Cooch Behar. The fresh fruits were cut into small pieces. The biochemical contents in fresh fruits were determined following protocols of for Total sugar and Malik and Singh (1980) for Total phenols content.

Statistical analysis

The data on percentage fruit infestation and biochemical fruit traits were analyzed through one-way ANOVA using SPSS 16 software (O’Connor 2000). The means of significant parameters, among tested varieties/ genotypes, were compared using Tukey’s honestly significant difference (HSD) test for paired comparisons at the 5% probability level. Correlations between biochemical fruit traits and fruit fly parameters (percent fruit infestation) were determined using correlation analysis and backward stepwise multiple regression analysis at the 95% significance level (Table 3).

Results and Discussion

Percent fruit infestation

Significant differences in percent fruit infestation were observed among the test cultivars in both the seasons (2014-15 and 2015-16) of study with three different stages i.e. Early, Pre-maturity and Maturity stages (Table 1 and Fig. 1).

Early stage of fruit infestation

Percent fruits infestation by the melon fly at Early stage varied significantly from 12.82% to 58.35% (Pooled data 2014-15 and 2015-16) being lowest infestation in V4 and highest in V1. Maximum percent fruit infestation was observed in V1, V13 and V19. Minimum percent fruit infestation was observed in cultivars V4, V11 and V5. Other varieties showed moderate percent fruit infestation.

Pre-maturity stage of fruit infestation

Percent fruits infested by the melon fly at Pre-maturity stage varied significantly from 15.97% to 59.31% (Pooled data 2014-15 and 2015-16) being lowest infestation in V4 and highest in V1. Maximum percent fruit infestation was observed in V1, V13 and V19. Minimum percent fruit infestation was observed in V4, V11 and V5. Other varieties showed moderate percent fruit infestation.

Maturity stage of fruit infestation

Percent fruits infested by the melon fly at maturity stage varied significantly from 20% to 61% (Pooled data 2014-15 and 2015-16) being lowest infestation in V4 and highest in V1. Maximum percent fruit infestation was observed in cultivars V1, V13 and V19. Minimum percent fruit infestation was observed in V4, V11 and V5. Other varieties showed moderate percent fruit infestation.

Biochemical fruit traits

Biochemical fruit traits of the pumpkin varieties/ genotypes was evaluated at three different stages of fruit i.e., Early stage (0-10 DAS), Pre- maturity stage (20-25 DAS) and Maturity stage (35-40 DAS) (Table 2).

Total sugar

Total sugar content in Early stage varied significantly from 183.90 to 316.11mg/g (Pooled data 2014-15 and 2015-16) with Maximum Total sugar content during Early stage of fruit observed in cultivars V1 (316.1^{a}), V13 (314.56^{b}) and V19 (314.47^{b}) and Minimum Total sugar content during Early stage of fruit were observed in V4 (183.90^{q}), V11 (207.16^{p}) and V5 (223.57^{o}).

Pre-maturity stage varied significantly from 322.02 to 427.84 mg/g (Pooled data 2014-15 and 2015-16) with Maximum Total sugar content during Early stage of fruit observed in cultivars V1(427.84^{a}), V13 (324.61^{b}) and V19 (272.15^{k}) and Minimum Total sugar content during Early stage of fruit observed in V4 (322.02^{c}), V11(319.83^{d}) and V5(301.33^{e}). Maturity stage varied significantly from 380.48 to 842.97 mg/g (Pooled data 2014-15 and 2015-16 with Maximum Total sugar content observed in V1 (842.97^{a}), V13 (826.01^{b}) and V19 (818.19^{c}) and Minimum Total sugar content observed in V4 (380.48^{s}), V11(392.89^{r}) and V5 (407.58^{q}).

Total phenol

Total Phenol content in Early stage varied significantly from 401.38 to 1373.32 mg/g (Pooled data 2014-15 and 2015-16) with Minimum Total Phenol content observed in cultivars V1(401.38^{k}), V13(422.97^{kj}) and V19(512.39^{ij}) and Maximum Total phenol content observed in V4(1373.32^{a}), V11(1290.33^{a}) and V5 (1187.03^{b}).

Table.1 Fruit infestation %

Varieties	Early				Pre-maturity				Maturity			
	2014	2015	Pooled	Resistance category	2014	2015	Pooled	Resistance category	2014	2015	Pooled	Resistance category
V1	58.29(49.59)^{k}	58.39(49.83)^{o}	58.35(49.80)^{b}	S	59.30(50.34)^{a}	59.31(50.35)^{a}	59.31(50.36)^{a}	S	61.08(51.37)^{c}	60.91(41.29)^{a}	61.00(51.35)^{a}	S
V2	55.00(48.02)^{o}	55.00(47.85)^{pq}	55.00(47.87)^{d}	S	56.54(48.71)^{j}	56.41(48.69)^{d}	56.48(48.72)^{c}	S	57.83(49.49)^{f}	57.86(36.99)^{j}	57.85(49.52)^{e}	S
V3	45.97(42.62)^{h}	45.98(42.71)^{i}	45.98(42.70)^{h}	MR	41.35(42.58)^{g}	46.27(42.80)^{g}	43.81(41.66)^{i}	MR	46.12(42.77)^{e}	46.12(39.12)^{d}	46.12(42.78)^{h}	MR
V4	12.85(20.23)^{d}	12.79(20.94)^{c}	12.82(20.98)^{p}	R	16.01(23.44)^{q}	15.93(23.48)^{q}	15.97(23.56)^{o}	R	20.00(26.53)^{j}	19.97(30.67)^{s}	20.00(26.57)^{q}	R
V5	21.28(27.33)^{ef}	21.13(27.35)^{e}	21.21(27.42)^{n}	MR	23.18(28.66)^{n}	21.46(27.46)^{o}	23.11(28.73)^{m}	MR	24.17(29.39)^{i}	24.14(31.64)^{r}	24.16(29.44)^{p}	MR
V6	25.30(29.83)^{f}	25.28(30.20)^{g}	25.29(30.19)^{l}	MR	22.79(28.15)^{p}	23.02(28.61)^{o}	22.13(28.06)^{m}	MR	25.82(30.49)^{fg}	26.29(32.07)^{p}	26.06(30.70)^{o}	MR
V7	48.93(44.16)^{g}	48.99(44.41)^{h}	48.96(44.41)^{e}	MR	49.14(44.53)^{b}	49.10(44.48)^{b}	49.12(44.50)^{de}	MR	49.99(44.87)^{b}	50(40.65)^{b}	50.00(45.00)^{f}	MR
V8	47.29(43.35)^{i}	47.04(43.27)^{j}	47.17(43.38)^{g}	MR	47.88(43.75)^{e}	47.86(43.79)^{f}	47.87(43.78)^{ef}	MR	48.43(44.12)^{de}	48.15(38.10)^{f}	48.29(44.02)^{g}	MR
V9	42.38(40.51)^{l}	42.40(40.65)^{n}	42.39(40.63)^{i}	MR	45.04(42.05)^{l}	45.03(42.13)^{k}	45.04(42.15)^{hi}	MR	45.51(42.36)^{m}	45.54(33.25)^{o}	45.53(42.44)^{l}	MR
V10	48.11(43.83)^{j}	48.17(43.95)^{m}	48.14(43.94)^{f}	MR	49.63(44.83)^{h}	49.70(44.82)^{i}	49.67(44.81)^{d}	MR	49.90(44.70)^{f}	49.91(35.67)^{l}	49.91(44.95)^{j}	MR
V11	17.64(24.47)^{a}	17.66(24.84)^{d}	17.65(24.84)^{o}	R	19.49(25.53)^{p}	19.48(26.18)^{p}	19.49(26.19)^{n}	R	20(26.53)^{d}	19.95(30.46)^{t}	19.98(26.55)^{r}	R
V12	47.25(43.21)^{gh}	47.19(43.38)^{i}	47.23(43.41)^{g}	MR	47.32(43.43)^{d}	47.29(43.44)^{e}	47.31(43.46)^{fg}	MR	47.76(43.61)^{c}	47.76(37.82)^{g}	47.76(43.72)^{i}	MR
V13	58.91(49.17)^{n}	58.95(50.17)^{p}	58.94(50.16)^{a}	S	58.19(49.60)^{c}	58.16(49.70)^{b}	58.18(49.71)^{ab}	S	60.23(50.91)^{i}	60.25(39.74)^{c}	60.25(50.91)^{b}	S
V14	55.19(47.90)^{m}	55.27(48.04)^{q}	55.23(48.00)^{d}	S	56.50(48.62)^{c}	56.49(48.73)^{d}	56.50(48.74)^{c}	S	57.99(49.65)^{l}	57.99(37.61)^{h}	58.00(49.60)^{d}	S
V15	22.44(28.03)^{e}	22.44(28.26)^{f}	22.45(28.28)^{m}	MR	24.64(29.66)^{o}	24.58(29.73)^{n}	24.61(29.74)^{l}	MR	26.02(30.70)^{h}	26.14(31.95)^{q}	26.09(30.71)^{o}	MR
V16	28.78(32.02)^{b}	28.77(32.43)^{b}	28.78(32.44)^{j}	MR	30.93(33.75)^{k}	30.90(33.76)^{l}	30.92(33.78)^{j}	MR	31.79(34.30)^{a}	31.84(37.13)^{i}	31.82(34.34)^{m}	MR
V17	25.97(30.40$^{)c}$	25.93(30.62)^{a}	25.95(30.63)^{k}	MR	26.53(30.98)^{m}	26.46(30.95)^{m}	26.50(30.98)^{k}	MR	27.26(31.45)^{c}	27.22(35.29)^{n}	27.24(31.46)^{n}	MR
V18	46.18(42.70)^{j}	46.21(42.82)^{k}	46.20(42.82)^{h}	MR	47.75(43.75)^{i}	47.79(43.71)^{h}	47.78(43.73)^{f}	MR	48.02(43.91)^{f}	48.02(36.83)^{k}	48.02(43.87)^{j}	MR
V19	56.89(48.90)^{n}	56.99(49.02)^{r}	56.95(48.99)^{c}	S	57.73(49.44)^{f}	57.78(49.47)^{c}	57.76(49.47)^{bc}	S	58.71(50.34)^{k}	58.72(38.85)^{e}	58.72(50.02)^{c}	S
V20	47.29(43.38)^{k}	47.35(43.50)^{l}	47.33(43.47)^{g}	MR	46.078(42.54)^{i}	46.07(42.75)^{j}	46.08(42.75)^{gh}	MR	46.02(42.71)^{gh}	45.99(35.40)^{m}	46.01(42.71)^{k}	MR

Values in parenthesis are angular-transformed xR- resistant, MR- moderately resistant, S- susceptible and HS- highly susceptible

Table.2 Biochemical parameters

Varieties	Total Sugar (mg/g) Early			Total Sugar (mg/g) Pre- maturity			Total Sugar (mg/g) Maturity			Total Phenol (mg/g) Early			Total Phenol (mg/g) Pre-maturity			Total Phenol (mg/g) Maturity		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
V1	314.17^{a}	318.18^{a}	316.1^{a}	427.18^{a}	428.50^{a}	427.84^{a}	805.08^{a}	880.85^{a}	842.97^{a}	376.88^{g}	425.87^{s}	401.38^{k}	460.11^{c}	498.75^{t}	479.4^{e}	526.25^{t}	608.755^{t}	567.51^{t}
V2	310.12^{b}	304.10^{d}	307.1183^{c}	324.75^{ab}	324.46^{b}	277.32^{j}	762.21^{c}	804.58^{d}	783.40^{e}	564.74^{efg}	597.26^{o}	581.01^{ih}	712.77^{b}	505.65^{s}	609.2^{de}	793.14^{p}	638.626^{p}	715.88^{p}
V3	249.4^{j}	273.02^{l}	261.2133^{l}	283.21^{h}	319.43^{f}	322.42^{c}	544.36^{g}	773.71^{f}	659.04^{f}	1020.38^{bcd}	711.88^{m}	866.14^{ed}	822.75^{b}	947.88^{j}	885.3^{cde}	885.11^{o}	711.735^{o}	798.43^{o}
V4	157.91^{m}	209.89^{r}	183.9067^{q}	214.19^{m}	214.79^{t}	322.02^{c}	368.87^{p}	392.08^{s}	380.48^{s}	1558.07^{a}	1188.55^{a}	1373.32^{a}	1589.62^{b}	1370.35^{a}	1480^{a}	1899.38^{a}	1693.10^{a}	1796.25^{a}
V5	201.72^{k}	245.42^{p}	223.575^{o}	269.05^{k}	262.79^{p}	301.33^{e}	394.68^{n}	420.46^{q}	407.58^{q}	1223.55^{bef}	1150.50^{c}	1187.03^{b}	1451.63^{b}	1347.11^{c}	1399.4^{ac}	1513.15^{c}	1403.51^{c}	1458.34^{c}
V6	257.27^{h}	254.56^{n}	255.92^{m}	277.77^{j}	254.58^{q}	269.13^{l}	467.09^{n}	558.89^{m}	512.99^{n}	632.53^{bcd}	1118.83^{d}	875.69^{ed}	1278.36^{b}	1067.55^{g}	1173^{c}	1314.75^{h}	1265.94^{h}	1290.35^{f}
V7	249.76^{j}	277.96^{j}	263.8633^{k}	270.98^{k}	267.27^{n}	298.16^{f}	563.76^{f}	713.45^{g}	638.61^{h}	1084.15^{d}	841.16^{i}	962.66^{cd}	1237.13^{b}	1265.65^{d}	1251.4^{c}	1298.7^{i}	1363.75^{i}	1331.23^{e}
V8	286.87^{e}	274.66^{k}	280.7667^{g}	282.14^{hi}	284.25^{h}	293.25^{g}	484.16^{k}	563.50^{l}	523.83^{m}	966.77^{e}	1101.1^{e}	1033.94^{c}	1012.65^{b}	1014.37^{h}	1013.5^{cde}	980.57^{m}	1003.15^{m}	991.87^{m}
V9	262.4^{g}	268.05^{m}	265.2567^{j}	308.88^{fg}	272.16^{m}	290.52^{h}	514.26^{i}	685.32^{i}	599.80^{j}	673.88^{d}	806.77^{j}	740.33^{g}	1178.05^{b}	1250.65^{e}	1214.4^{c}	1200.1^{j}	1342.62^{j}	1271.36^{g}
V10	252.65^{i}	288.18^{g}	270.4217^{i}	280.04^{ij}	264.25^{o}	290.52^{h}	564.26^{f}	632.46k	598.37^{j}	868.62^{a}	878.05^{g}	873.34^{ed}	1083.15^{b}	900.15^{l}	991.7^{cde}	886.65^{n}	978.755^{n}	932.70^{n}
V11	178.90^{l}	235.42^{q}	207.165^{p}	224.85^{l}	230.97^{r}	319.83^{d}	376.61^{o}	409.17^{r}	392.89^{r}	1417.77^{d}	1162.88^{b}	1290.33^{a}	1475.05^{b}	1354.88^{b}	1415^{ac}	1805.16^{b}	1436^{b}	1620.58^{b}
V12	287.14^{e}	287.29^{i}	287.2217^{f}	310.29^{f}	276.18^{j}	282.32^{i}	576.37^{e}	558.89^{m}	567.63^{k}	976.86^{fg}	754.36^{k}	865.61^{ed}	1107.86^{b}	855.83^{m}	981.9^{cde}	1137.23^{l}	927.065^{l}	1032.15^{l}
V13	315.18^{a}	313.95^{b}	314.565^{b}	319.17^{de}	320.48^{e}	324.61^{b}	803.29^{a}	848.72^{b}	826.01^{b}	414.55^{efg}	431382^{r}	422.97^{kj}	530.385^{b}	564.26^{p}	547.3^{de}	595.11^{s}	640.387^{s}	617.75^{s}
V14	316.22^{a}	312.60^{b}	314.4183^{b}	323.27^{bc}	321.56^{d}	220.68^{o}	795.64^{b}	784.42^{e}	790.04^{d}	557.27^{bc}	572.60^{p}	564.94^{i}	609.75^{b}	547.78^{q}	578.8^{de}	655.61^{q}	706.392^{q}	681.01^{q}
V15	250.02^{j}	252.54^{o}	251.2833^{n}	275.88^{m}	265.47^{s}	270.67^{i}	474.27^{l}	533.17^{o}	503.72^{p}	1195.52^{efg}	1150.55^{c}	1173.04^{b}	881.55^{b}	1164.26^{f}	1022.9^{cde}	1329.77^{g}	1363.41^{g}	1346.60^{d}
V16	264.12fg	298.84^{g}	281.4833^{g}	280.48^{hji}	274.16^{l}	266.18^{m}	496.87^{j}	554.15^{n}	525.52^{l}	585.35^{ef}	921.76^{f}	753.56^{gf}	1108.35^{b}	1003.35^{i}	1055.9^{cd}	595.11^{k}	1234.15^{k}	1204.27^{h}
V17	265.15^{f}	291.41^{j}	278.285^{h}	278.76^{j}	285.87^{g}	265.92^{m}	535.76^{h}	474.86^{p}	505.31^{o}	625.41^{ef}	877.31^{h}	751.36^{gf}	1082.65^{b}	936.86^{k}	1009.8^{cde}	655.61^{f}	1004.12^{f}	1175.20^{j}
V18	299.72^{d}	303.15^{e}	301.4383^{e}	317.17^{e}	279.15^{i}	227.92^{n}	565.76^{f}	646.96^{j}	606.36^{i}	614.82^{efg}	713.75^{l}	664.29^{gh}	957.26^{b}	852.85^{n}	905.1^{cde}	1329.77^{d}	954.72^{d}	1186.67^{l}
V19	314.19^{a}	314.76^{b}	314.4767^{b}	321.76^{cd}	322.27^{c}	272.15^{k}	805.5^{a}	830.87^{c}	818.19^{c}	474.61^{cd}	550.16^{q}	512.39^{ij}	555.55^{a}	542.87^{r}	549.21^{a}	1174.38^{r}	691.25^{r}	650.01^{r}
V20	305.15^{c}	301.17^{f}	303.165^{d}	306.36^{g}	274.67^{k}	214.49^{p}	604.16^{d}	698.76^{h}	651.46^{g}	1007.16	684.95^{n}	846.06^{ef}	1006.75^{b}	742.63^{o}	874.7^{cde}	1346.27^{e}	856.41^{e}	1116.77^{k}

Values in parenthesis are angular-transformed

Table.3 Correlation coefficient (r) between percent fruit infestation with different biochemical fruit traits of pumpkin varieties/ genotypes

	TSE	TSP	TSM	TPE	TPP	TPM	EI	PI	MI
EI	.861**	.886**	.912**	-.802**	-.525*	-.881**	1	.995**	.994**
PI	.853**	.877**	.908**	-.798**	-.515*	-.868**	.995**	1	.998**
MI	.843**	.881**	.921**	-.803**	-.522*	-.876**	.994**	.998**	1

** Significant at *P* = 0.01 (two-tailed).
*Significant at *P* =0.05 (two-tailed).

Fig.1 Graph showing percentage of fruit infestation at early, pre-maturity and maturity stage

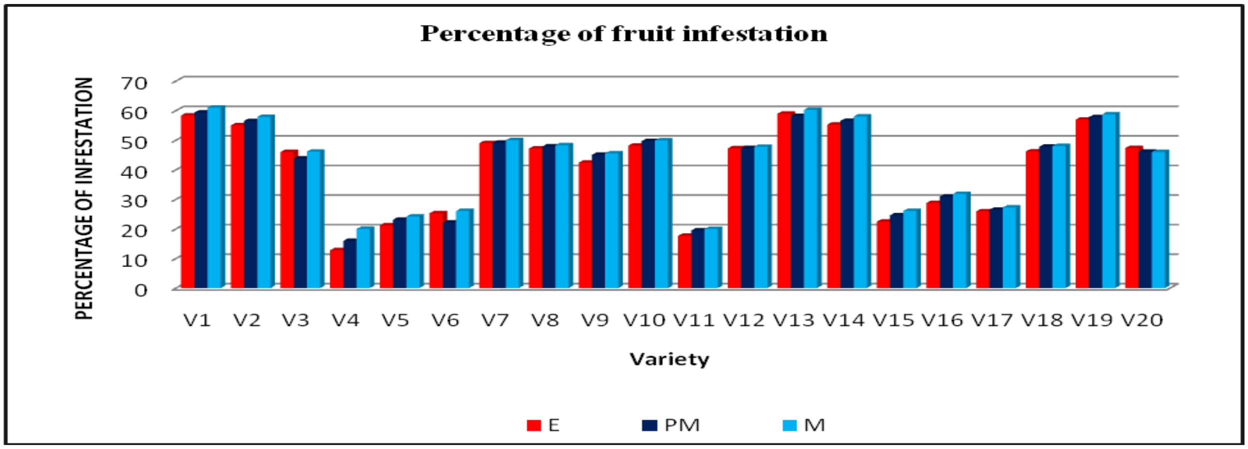
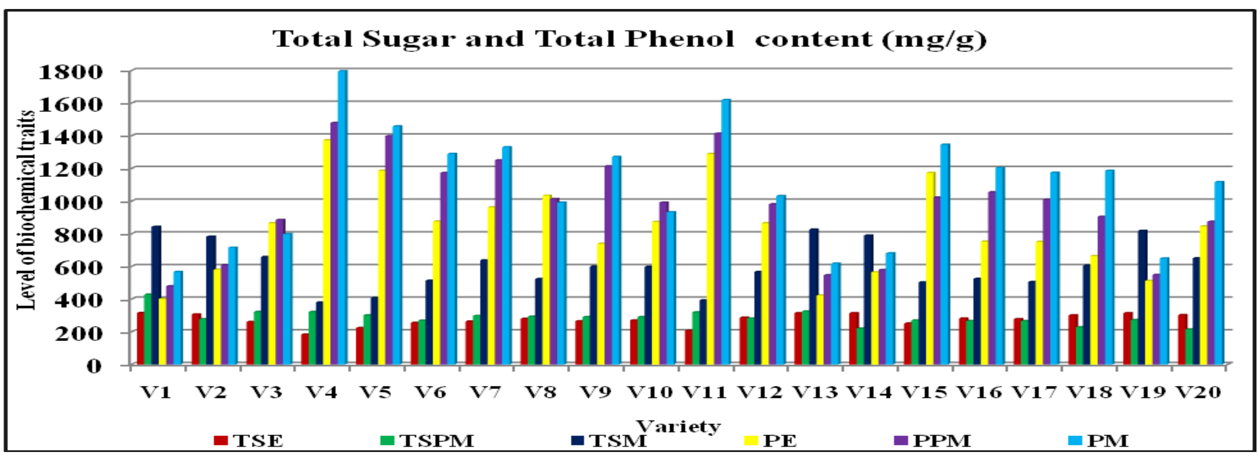


Fig.2 Graph showing



Pre-maturity stage varied significantly from 479.4 to 1480 mg/g (Pooled data 2014-15 and 2015-16) with Minimum Total Phenol content observed in cultivars V1 (479.4[e]), V13(547.3[de]) and V19 (549.21[a]) and Maximum Total phenol content observed in V4 (1480[a]), V11 (1415[ac]) and V5 (1399.4[ac]).

Maturity stage varied significantly from 567.51 to 1796.25 mg/g (Pooled data 2014-15 and 2015-16) with Minimum Total Phenol content observed in cultivars V1(567.51[t]), V13(617.75[s]) and V19(650.01[r]) and Maximum Total phenol content observed in V4(1796.25[a]), V11(1620.58[b]) and

V5(1458.34[c]). Other varieties showed moderate content.

EI- Early Infestation %, PI- Pre-maturity Infestation %, MI- Maturity Infestation%, TSE- Total Sugar at Early stage, TSP- Total Sugar at Pre-maturity stage (mg/g), TSM- Total Sugar at Maturity stage (mg/g), TPE- Total Phenol at Early stage (mg/g), TPP- Total Phenol at Pre-maturity stage (mg/g), TPM- Total Phenol at Maturity stage (mg/g).

Total sugar content of fruit at Early stage, Pre-maturity stage and Maturity stage had a highly significant positive correlation (P=0.01) with Early Infestation %, Pre-maturity infestation % and Maturity Infestation %. Total Phenol content at early stage and Maturity Stage of fruit had a highly significant negative correlation with the Early Infestation %, Pre- maturity infestation % and Maturity Infestation % whereas Total Phenol content at Pre-maturity stage had a significant negative correlation.

Host plant selection by insects is expressed either by the occurrence of a population of insects on the plant in nature or by feeding, oviposition or use of the plant for complete offspring development (Rafiq *et al.,* 2008; Thronsteinson, 1953). Selection is regulated primarily by chemoreception (Gogi *et al.*, 2010b; Jeremy and Szentesi, 2003). Plant varieties/ genotypes possess physiological and biochemical variations due to the environmental stress or genetic makeup, which alter the nutritional values for herbivores (Gogi *et al.*, 2010b; Misirli *et al.*, 2000; Rafiq *et al.,* 2008).

In the present study, Varieties V4 and V11 were the most resistant; and V1, V13, V19, V14 and V2 were susceptible; V3, V5, V6, V7, V8, V9, V12, V15, V16, V17, V18 and V20 were moderately resistant in both seasons. The percent fruit infestation was significantly lower in resistant varieties/ genotypes and higher in susceptible varieties/ genotypes of Pumpkin.

Numerous studies have shown that varieties/ genotypes of the same species could differ significantly in their resistance to insect pests (Dhillon *et al.,* 2005a; Gogi *et al.,* 2009; Sarfraz *et al.,* 2006; Weems and Heppner 2001) and it is caused by biochemical traits of plants.

The allelochemical compounds of fruit were significantly different among the tested pumpkin varieties/ genotypes. Total sugar was lowest in resistant and highest in susceptible varieties/ genotypes, whereas phenol content was highest in resistant and lowest in susceptible varieties/ genotypes. Total sugar, reducing sugar, non-reducing sugar and pH of fruit had a significant positive correlation, whereas tannins, phenols, alkaloids and flavinoid contents had significant negative correlations with the percent fruit infestation and the larval density per fruit. Sharma and Hall (1971) reported a positive correlation between spotted cucumber beetle (*Diabrotica undecimpunctata*) feeding and total sugars of various cucurbitaceous crops. In the okra crop, the biochemical characters such as total sugar and crude protein were positively correlated with fruit borer infestation, whereas total phenols were negatively correlated (Ilango and Uthamasamy, 1989; Jat and Pareek, 2003; Sharma and Singh 2010). Similar to our findings, phenols, tannins, and flavonoids enhanced plant defenses against insects (Gogi *et al.*, 2010b; Mila and Scalbert 1994; Ryan and Robards, 1998; Tomas-Barberan *et al.,* 1988). Reduction of fruit fly infestations on resistant varieties/ genotypes could be due to antibiosis (allelochemicals) and our results suggest that biochemical fruit traits could contribute to these mechanisms of resistance. In summary, certain biochemical traits (e.g. total sugar and phenol contents) (Fig. 2) were linked to resistance of Pumpkin against *B. cucurbitae* and therefore can be used as marker traits in plant breeding programs to select resistant varieties/ genotypes.

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