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Studies on the Relationship between Agronomic and Fruit Quality traits of *Passiflora* species found in India's NEH region

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ABSTRACT: Improvement work for morphological and biochemical characters especially in *Passiflora edulis* Sim, *Passiflora ligularis* Juss, *Passiflora edulis* f. *flavicarpa* and *Passiflora quadrangularis* L. is complicated due to polygenic additive nature of traits among them. North East Region of India has diverse climatic and wide edaphological conditions from valley to upper hills having wide potential for commercialization of *Passiflora* species. Therefore, studies focused on evaluation of genetic variability components and correlations within morphological and biochemical characters collected from North East Region of India during 2018 to 2020. Fruit yield /vine had the highest genotypic coefficient of variation, whereas number of fruits /vine, number of seeds /fruit, and fruit weight had high heritability with high genetic advance, and correlation studies revealed that number of fruits/vine had the strongest significant positive correlation with fruit yield /vine (kg) for morphological characters. Biochemical traits of Vitamin A content and juice content /fruit (mL) have highest genotypic coefficient of variation and high heritability, whereas correlations studies revealed that total soluble solid had strongest significant positive correlation with juice content /fruit (mL) which indicate scope for interspecific crosses among *Passiflora* species found in North East India in the future.

Keywords: *Passiflora edulis* Sim, *Passiflora ligularis* Juss, *Passiflora edulis* f. *flavicarpa*, *Passiflora quadrangularis* L., correlation, NEH Region

INTRODUCTION

The NEH region of India has diverse number of underexploited fruits including different passion fruit species, especially *P. edulis* Sim, *P. edulis* f. *flavicarpa*, *P. quadrangularis* L. as well as *P. ligularis* Juss in some part of Kohima, Nagaland and Ukhrul district, Manipur. In India passion fruit is less emphasized fruit but it bears a delicious purple, yellow as well yellowish purple with white speckles fruit. Purple passion fruit are morphologically smaller than the yellow type having a size of about 4 to 5 cm in diameter having an average fruit weight from 37-50 g/fruit and deep purple in colour at ripened stage. The edible portion of passion fruit is the mass of yellow-orange pulp which surrounds numerous small black seeds attached to peg-like funuli with in ovary wall (Tripathi *et al.* 2014). Yellow type (*P. edulis* f. *flavicarpa*) has more vigorous vine, ideal for lower elevation due to its sensitivity to low temperature, and is less successful at higher elevation as compare to purple type. Yellow passion fruits are larger (weight about 60 g) than the purple round variety with yellow mottled spots, turning to golden yellow when mature. The fruit juice of yellow passion fruit is more acidic as compare to the purple variety as well recover percentage is also comparatively less (Joy, 2010: Rao *et al*. 2014; Ali *et al*., 2021). The total area under passion fruit cultivation is about 0.014 mha and production of 0.082 mt in India during 2018 (Anon, 2020).

Fresh passion fruit leaves are consumed as a leafy vegetable in Nagaland, and the leaves' extract is used to cure diarrhoea and hypertension (Jamir *et al*., 1999). In South America, passion fruit is used as a sedative, diuretic, anthelmintic, anti-diarrheal, stimulant, tonic, and for the treatment of hypertension, menopause symptoms, and infant colic (Chopra *et al*., 1956; Kirtikar and Basu, 1975; Mowrey, 1993). Besides, in other parts of North East Hilly Region of India *viz.* Arunachal Pradesh, Mizoram and Manipur also used as leafy vegetable from its new shoot. In North East India most of underutilized fruits are also used as life-sustaining diversified food bases as well as nutrient security of rural people entire year (Singh *et al*. 2014). Heritability (broad sense), genetic advance, phenotypic and genotypic correlation coefficients among different

morphological and biochemical characters were estimated among its variables, as well as the scope and response of selection for various traits with respect to coefficients of variability at the phenotypic and genotypic level. As a result, the current study was started to investigate the genetic variability and correlation of passion fruit genotypes found in North East Region of India based on morphological and biochemical characteristics.

MATERIALS AND METHODS

Arunachal Pradesh, Assam, Manipur, Mizoram, Nagaland, Sikkim, and Tripura were used to collect fifteen genotypes of four *Passiflora* species *viz*. *P. edulis* Sim, *P. edulis* f. *flavicarpa*, *P. quadrangularis* L., and *P. ligularis* Juss. Plant samples, such as leaves and fruits, were gathered and brought to the Department of Fruit Science, CHF, CAU, Pasighat, Arunachal Pradesh during the study (2018-2020). The coefficients of variability at the phenotypic and genotypic levels, heritability (in the broad sense), genetic progression, and phenotypic and genotypic correlation coefficients among variables for morphological and biochemical features were all investigated.

The collection comprises contrast climatic (temperature range 16°C/32°C) and edaphological condition as well having more than 1000 mm of annual rainfall in different regions of North East India (Dikshit and Dikshit, 2014).

Table 1: List of Collected *Passiflora* species of North East India and their sources.

Sr. No.	Species	Code	Sources	Latitude	Longitude	Altitude
1.	*P. edulis* f. *flavicarpa* Deg	P1	Andro, Manipur	24°73' N	94°04' E	815 m
2.	*P. edulis* f. *flavicarpa* Deg	P2	West Imphal, Manipur	24°47' N	93°58' E	906 m
3.	*P. edulis* f. *flavicarpa* Deg	P3	Sutamura, west Tripura, Tripura	23°62' N	91°26' N	20 m
4	*P. edulis* f. *flavicarpa* Deg	P4	College of Agriculture, Biswanath Cherali, Assam	26°43' N	93°08' N	82 m
5.	*P. edulis* f. *flavicarpa* Deg	P5	Notun Basti, Dimapur, Nagaland	25°55' N	93°43' N	154 m
6.	*P. edulis* f. *flavicarpa* Deg	P6	CHF, Pasighat, Arunachal Pradesh	28°04' N	95°19' N	162 m
7.	*P. edulis* Sim	P7	Kangpokpi, Manipur	24°42' N	93°46' E	1510 m
8.	*P. edulis* Sim	P8	ICAR-NOFRI, East Sikkim	27°17' N	88°36' N	882 m
9.	*P. edulis* Sim	P9	Aizawl, Mizoram	23°43' N	92°44' N	786 m
10.	*P. edulis* Sim	P10	CHF, Campus, Pasighat, Arunachal Pradesh	28°04' N	95°19' N	168 m
11.	*P. edulis* Sim	P11	Ziro, Lower Subansiri, Arunachal Pradesh	27°32' N	93°48' N	1566 m
12.	*P. edulis* Sim	P12	Pasighat, Arunachal Pradesh	28°03' N	95°20' N	154 m
13.	*P. ligularis* Juss	P13	Lunghar Village, Ukhrul, Manipur	25°16' N	94°42' E	1633 m
14.	*P. ligularis* Juss	P14	Sakhabama, Kohima, Nagaland	25°39' N	94°11' N	1077 m
15.	*P. quadrangularis* L.	P15	Pasighat, Arunachal Pradesh	28°03' N	95°20' N	156 m

For morphological variables, the variables were leaf length (cm), leaf breadth (cm), tendril length (cm), flower length (cm), number of flower/node, fruit length (cm), fruit breadth (cm), fruit weight (g), number of fruits/vine, fruit yield/vine (kg), peel weight (g), seed length (cm), seed breadth (cm), seed weight/fruit (g), seed length/fruit (g) and seed weight/fruit (g) and Juice content/fruit (mL), Total soluble solid content determined by hand refractometer and valuated in °Brix; titratable acidity of extracted juice was determined by titrimatric method against N/10 phenolphthalein indicator was used to determine the concentration of NaOH in the solution, which was then expressed as a percentage of citric acid. (AOAC, 2005); Vitamin C content content of fruit juice and leaves were determined by the strategy depicted by Ranganna (1986) in which 5 mL of fruit juice was blended with 3% metaphosphoric acid, diluted to 50 mL with metaphosphoric acid, filtered, and then titrated a 5 mL aliquot with standard dye to a pink colour end point that lasted at least 15 seconds and was expressed in mg 100-1 (g); Total carbohydrate content was determined using Hedge and Hofreiter's strategy (1962) in which 1 mL of fruit juice hydrolyzed with 2.5 N of dilute HCL and absorption was taken at 630 nm and expressed in percentage; reducing sugar content was determined by spectrophotometric method in which mL fruit juice mixed with 5 mL of hot 80% ethanol, data calculated in percentage; non–reducing sugar content was determined by withdrawing the reducing sugar by multiplying the total carbohydrate by 0.95 and expressing it as a percentage (Kumar 2002); Vitamin A content was estimated by taking 1 mL fruit juice to 10 mL of saponification mixture, Petroleum ether was

added to tubes that had been refluxed for 20 minutes at 60° C. was added with sodium sulphate (anhydrous) to removed the moisture for a half hour and dryness at 60° C as described by Bayfield and Cole (1980) and expressed in mg 100^{-1} (g); total flavonoid content in which 0.30 mL of 5 percent sodium nitrate was added to 1 mL of extract and 4 mL of distilled water, followed by 0.3 mL of 10% aluminium chloride after 5 minutes. After 5 minutes, 2 mL of 1 M NaOH was treated and diluted to 10 mL with distilled water, and the data was computed and represented in mg 100 g using a spectrophotometer. (g) as described by Vijay and Rajendra (2014), Antioxidant activity was determined in which 1 mL of fruit juice was taken and homogenized in 5 mL of ethanol. 0.5 mL of sample extract, 0.3 mL of DPPH reagent (0.5 Mm in ethanol) was added and reading was taken at 517 nm and data was expressed in mg 100^{-1} (g) for biochemical characters.

Variability coefficients at the phenotypic and genotypic levels, heritability (in the broad sense), genetic progress, and phenotypic and genotypic variability of pearson's correlation between several morphological and biochemical variables were interpreted at 1% and 5% significance, and the data were statistically analysed.

RESULTS AND DISCUSSION

The highest genotypic and PCV was recorded as fruit yield/vine and least for seed length and data conformity with Santos *et al*. (2017); Negreiros *et al*. (2007). Fruit weight and number of fruits per vine have high heritability and genetic progress, implying that these features are subject to additive gene effects and thus more trustworthy for effective selection (Burton and de Vane, 1953; Panse, 1957). The quantity of fruits/vine exhibited the strongest significant positive link, according to correlation studies with fruit yield (kg)/ vine while number of flower/node with fruit yield /vine had strongest significant negative correlation both at genotypic and phenotypic level which suggested the significance of these traits which is directly proportional to productivity in selection for yield traits. Similar findings recorded by Weber *et al*. (2014); Haddad (1968) in *P. edulis* f. *flavicarpa*, Matins *et al*. (2003) in *P. ligularis* Juss.

Table 2: Mean value of characters of *Passiflora* species found in North East India.

Species	Geno-types code	FL	LL	LB	TL	NFN	FL	FB	FW	NFV	PW	SL	SB	SWF	FY
P. edulis f. *flavicarpa* Deg	P_1	6.93	12.56	16.07	13.00	1.00	6.17	5.33	78.75	140.67	42.85	0.54	0.35	2.91	9.95
P. edulis f. *flavicarpa* Deg	P2	6.86	12.21	15.56	12.50	1.00	6.63	6.16	65.10	138.33	42.32	0.56	0.38	2.07	9.01
P. edulis f. *flavicarpa* Deg	P3	5.60	11.23	14.10	16.00	1.00	6.15	5.23	69.98	144.00	43.34	0.54	0.35	2.54	10.07
P. edulis f. *flavicarpa* Deg	P4	5.60	12.70	15.67	20.00	1.00	6.46	5.59	76.47	120.00	43.29	0.51	0.38	3.12	9.16
P. edulis f. *flavicarpa* Deg	P5	6.73	10.20	12.68	14.50	1.33	5.95	5.02	45.18	128.00	20.59	0.52	0.19	3.27	5.79
P. edulis f. *flavicarpa* Deg	P6	7.40	11.27	14.80	22.50	1.00	6.51	5.64	77.69	118.00	47.95	0.52	0.37	3.04	10.47
P. edulis Sim	P7	6.30	10.68	13.24	20.00	1.00	5.95	5.02	45.18	166.67	24.59	0.51	0.20	3.23	7.56
P. edulis Sim	P8	5.93	10.86	13.92	19.00	1.00	4.79	4.27	32.70	159.67	16.29	0.52	0.21	2.31	5.23
P. edulis Sim	P9	5.73	10.62	13.11	18.50	1.00	4.69	4.20	31.78	152.67	15.90	0.49	0.19	1.60	4.85
P. edulis Sim	P10	7.73	15.13	12.07	22.00	1.00	6.06	5.12	33.08	161.33	16.17	0.54	0.35	3.15	5.36
P. edulis Sim	P11	5.76	10.41	12.64	20.00	1.00	5.68	4.80	43.99	157.67	22.86	0.51	0.20	2.97	6.95
P. edulis Sim	P12	5.86	10.42	13.28	19.00	2.00	5.72	4.73	43.69	174.67	21.52	0.51	0.19	2.83	7.68
P. ligularis Juss	P13	6.00	14.45	10.51	14.00	1.67	7.18	5.38	55.06	91.67	31.34	0.60	0.17	5.27	5.04
P. ligularis Juss	P14	5.96	14.38	11.58	16.00	1.67	7.02	5.26	53.40	102.33	30.23	0.58	0.16	5.16	5.46
P. quadrangularis L.	P15	9.20	11.95	9.44	28.00	2.67	14.48	9.30	496.67	52.33	360.00	0.79	0.62	9.37	26.23
	Mean	6.51	11.94	13.24	18.33	1.29	6.63	5.40	83.25	133.87	51.95	0.55	0.29	3.52	8.59
	CV (%)	1.77	6.14	7.22	2.44	1.74	6.14	6.56	8.83	11.12	11.54	3.56	8.81	3.46	13.72
	SE(m)±	0.07	0.42	0.55	0.26	0.18	0.24	0.21	19.59	5.88	17.16	0.01	0.02	0.33	1.31
	C.D (5 %)	0.19	1.23	1.61	0.76	0.51	0.69	0.60	8.06	7.69	5.76	0.03	0.04	0.96	3.04

FL: flower length (cm), LL: leaf length (cm), LB: leaf breadth (cm), TL: tendril length (cm), NFN: number of flower/node, FL: fruit length (cm), FB: fruit breadth (cm), FW: fruit weight (g), NFV: number of fruits/vine, PW: peel weight (g), SL: seed length (cm), SB: seed breadth (cm), SWF: seed weight $fruit^{-1}$ (g), FY: fruit yield/vine (kg)

Table 3: Phenotypic correlation coefficients (r_p) of morphological traits of *Passiflora* species.

Correlation Matrix	FL	LL	LB	TL	NFN	FL	FB	FW	NFV	PW	SL	SB	SWF	FY
FL	**1.000**	0.192*	-0.310	0.522	0.445**	0.738**	0.760**	0.241**	-0.422 **	0.253	0.692**	0.749**	0.575	0.694**
LL		**1.000**	-0.111	-0.081*	-0.008	0.182	0.166	0.110	-0.371 *	0.117	0.293	0.151	0.263	-0.085
LB			**1.000**	-0.359	-0.561*	0.528**	0.361**	0.321*	0.479 ***	0.271	0.551**	0.010**	-0.737	-0.179**
TL				**1.000**	0.398	0.535**	0.480**	0.018**	-0.120	-0.032	0.407**	0.483**	0.503	0.554**
NFN					**1.000**	0.702	0.628**	0.061**	-0.537 ***	0.054	0.671**	0.327***	0.710	0.585**
FL						**1.000**	0.947	0.395**	-0.775 ***	0.413	0.930**	0.739***	0.886*	0.831**
FB							**1.000**	0.506	.702 ***	0.533	0.859**	0.820***	0.767*	0.881**
FW								**1.000**	-0.451 **	0.947	0.307	0.594*	0.211**	0.553
NFV									**1.000**	-0.468	0.788**	0.430**	-0.790*	-0.473
PW										**1.000**	0.332	0.601*	0.214**	0.536
SL											**1.000**	0.665	0.863*	0.726**
SB												**1.000**	0.435*	0.832**
SWF													**1.000**	0.620
FY														**1.000**

**, * significant at 1 and 5%, respectively

FL: flower length (cm), LL: leaf length (cm), LB: leaf breadth (cm), TL: tendril length (cm), NFN: number of flower/node, FL: fruit length (cm), FB: fruit breadth (cm), FW: fruit weight (g), NFV: number of fruits/vine, PW: peel weight (g), SL: seed length (cm), SB: seed breadth (cm), SWF: seed weight fruit^{-1} (g), FY: fruit yield/vine (kg)

Table 4: Genotypic correlation coefficients (r_p) of morphological traits of *Passiflora* species.

Correlation Matrix	FL	LL	LB	TL	NFN	FL	FB	FW	NFV	PW	SL	SB	SWF	FY
FL	**1.000**	0.215	-0.355	0.531*	0.523*	0.760**	0.804**	0.253	-0.452	0.264	0.712**	0.764**	0.607*	0.733**
LL		**1.000**	-0.344	-0.103	0.064	0.222	0.225	0.13	-0.492	0.18	0.342	0.164	0.321	-0.124
LB			**1.000**	-0.424	-0.723**	-0.588*	-0.418	0.393	0.513	0.377	-0.668**	-0.004	-0.821**	-0.231
TL				**1.000**	0.471	0.549*	0.51	-0.021	-0.125	-0.031	0.432	0.501	0.533*	0.605*
NFN					**1.000**	0.851**	0.742**	0.107	-0.641**	0.097	0.858**	0.388	0.907**	0.665**
FL						**1.000**	0.985**	0.422	-0.799**	0.433	0.994**	0.754**	0.937**	0.910**
FB							**1.000**	0.542*	-0.744**	0.558*	0.961**	0.868**	0.848**	0.933**
FW								**1.000**	-0.505	0.925**	0.354	0.645**	0.201	0.576*
NFV									**1.000**	-0.5	-0.860**	-0.459	-0.839**	-0.571*
PW										**1.000**	0.394	0.661**	0.215	0.584*
SL											**1.000**	0.687**	0.957**	0.828**
SB												**1.000**	0.481	0.908**
SWF													**1.000**	0.683**
FY														**1.000**

**, * significant at 1 and 5%, respectively

FL: flower length (cm), LL: leaf length (cm), LB: leaf breadth (cm), TL: tendril length (cm), NFN: number of flower/node, FL: fruit length (cm), FB: fruit breadth (cm), FW: fruit weight (g), NFV: number of fruits vine^{-1}, PW: peel weight (g), SL: seed length (cm), SB: seed breadth (cm), SWF: seed weight/fruit (g), FY: fruit yield/vine (kg)

Table 5: Genetic parameters for biochemical characters of *Passiflora* species.

Genetic Parameters	Genotypic Variance	Genetic coefficient of variability	Phenotypic Variance	Phenotypic coefficient of variability	h^2 (Broad Sense)	Genetic Advancement 5%
FJ	258.94	65.16	290.48	69.01	89.10	31.30
VC	28.78	22.89	40.47	27.15	71.10	9.32
TSS	2.32	9.21	2.40	9.36	96.70	3.09
VA	591.98	102.39	592.99	102.47	99.80	50.08
TF	53.12	46.22	73.52	54.38	72.30	12.76
AA	13.02	30.79	16.64	34.81	78.30	6.58
TA	1.12	44.06	1.21	45.74	92.80	2.10
TC	1.98	13.17	2.88	15.89	68.80	2.40
RS	1.01	18.93	1.40	22.34	71.80	1.75
NRS	0.75	16.80	2.56	30.98	29.40	0.97

FJ: Fruit juice (mL/fruit), VC: vit-c (mg/100 g), TSS: total soluble solids (°Brix), VA: Vit. A (mg/100 g), TF: total flavonoids (mg/100 g), AA: Antioxidant activity (DPPH) (%), TA: titratable acidity (%), TC: total carbohydrate (%), RS: reducing sugar (%), NRS: non-reducing sugar (%)

Table 6: Phenotypic correlation coefficients (r_p) of biochemical characters in collected *Passiflora* species.

Correlation matrix	VC	TSS	VA	TF	AA	TA	TC	RS	NRS	FJ
VC	**1.000**	-0.246	0.111	0.016	0.318 *	0.493 **	0.424 *	0.398 **	0.303 *	0.318
TSS		**1.000**	0.556 **	0.362 *	0.370 *	-0.061	0.060	0.326 *	-0.156	-0.551
VA			**1.000**	0.657 **	0.594 **	0.066	0.396 *	0.736 ***	-0.070	-0.400
TF				**1.000**	0.568 **	-0.270	-0.054	0.502 ***	-0.288	-0.046
AA					**1.000**	0.172	0.312 *	0.493 ***	0.065	-0.299
TA						**1.000**	0.485 **	0.111	0.452 **	-0.013
TC							**1.000**	0.477 ***	0.398 **	-0.214
RS								**1.000**	-0.010	-0.091
NRS									**1.000**	-0.033
FJ										**1.000**

**, * significant at 1 and 5%, respectively
FJ: Fruit juice (mL/fruit), VC: vit-c (mg/100 g), TSS: total soluble solids (°Brix), VA: Vit. A (mg/100 g), TF: total flavonoids (mg/100 g), AA: Antioxidant activity (DPPH) (%), TA: titratable acidity (%), TC: total carbohydrate (%), RS: reducing sugar (%), NRS: non-reducing sugar (%)

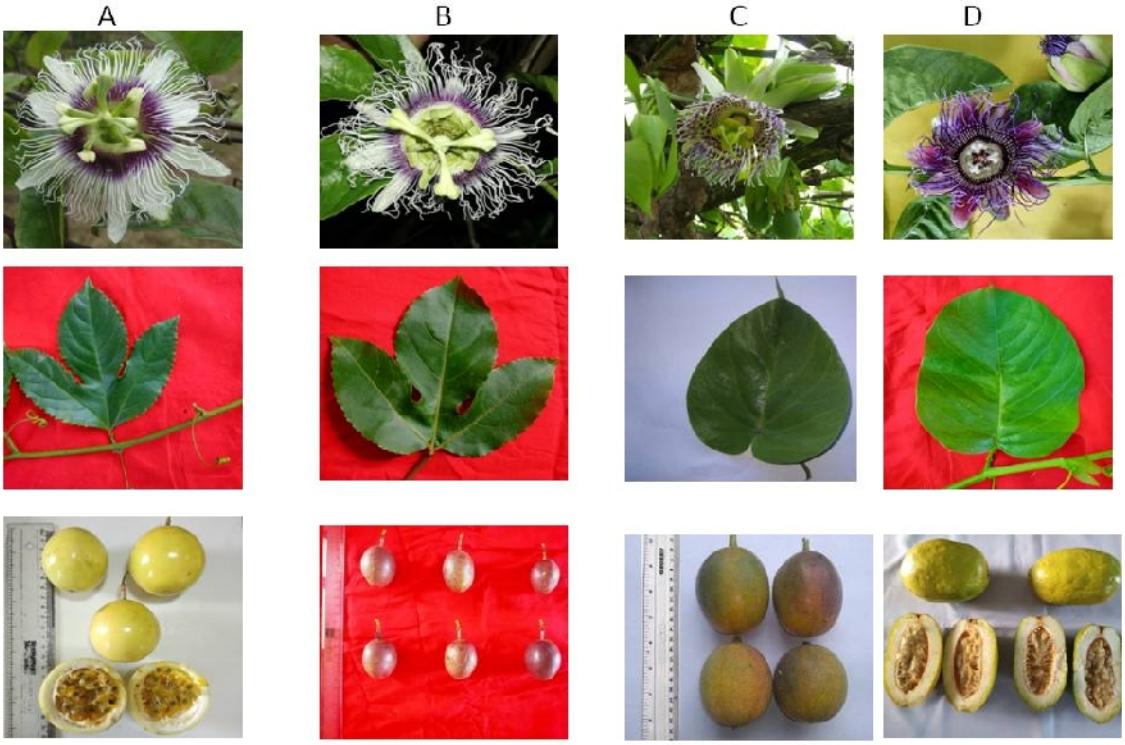

Fig. 1. Genetic variability component and correlation studies in (A). *Passiflora edulis* f. *flavicarpa* (B). *Passiflora edulis* Sim (C) *Passiflora ligularis* A. Juss and (D) *Passiflora quadrangularis* L. found in North East region of India.

Under genetic variability components highest GCV observed for vitamin A content followed by juice content/fruit (mL) whereas the lowest estimates was recorded for total soluble solid content and total carbohydrate content and result was in conformity with Weber *et al*. (2014); Santos *et al*. (2017). High heritability (broad sense) and high GA estimates had shown *viz.* vitamin A content followed by total soluble solid content.

Total soluble solid exhibited the strongest significant positive link with juice content/fruit (mL) in pearson's correlation analyses, indicating that phenotypic level indicated the importance of these qualities in selection for juice content, and similar results were also reported by Santos *et al.* (2017).

CONCLUSION

Genotypic and phenotypic coefficients of variation were found strongest for fruit yield /vine (kg). The characters like, tendril length and Vitamin A content are under additive gene effects and hence these characters are more reliable for effective selection. Hence, selection on the basis of these traits will be more useful for the improvement of this crop towards higher fruit yield and quality production. Correlation studies revealed that number of fruits vine^{-1} had significant positive correlation with fruit yield/vine (kg) whereas total flavonoids had significant positive correlation with juice content/fruit (mL) which indicated the importance of these traits in selection for yield. Direct selection based on these traits would result in simultaneous improvement of aforesaid traits and fruit yield /vine in *Passiflora* species. From the experiment, it is concluded that the correlation studies of morphological and biochemical traits of *Passiflora* species found in North East India predict the interspecific relation among them which will be helpful for crop improvement works in the future.

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REFERENCES

Ali, U., Jatoi, G. H., Khuhro, S. A., Shar, T., Ahmad, R. and Khatoon, M. (2021). Potassium Management for the Improvement of Growth and Yield of Grass Pea (*Lathyrus sativus* L.). *International Journal on Emerging Technologies*, *12*(1): 181-187.

Anonymous, (2020). Passion fruit area and production. In: Ministry of Agriculture and Farmers Welfare, Horticultural statistics-Agricoop 2020, p. 9. Government of India.

AOAC, (2005). Official Methods of Analysis of AOAC International, 18th edn. Gaithersburg, USA, p. 210.

Arnon, D. I. (1949). Copper enzymes in isolated chloroplasts polyphenoloxidase in *Beta vulgaris*. *Plant Physiol.*, *24*: 1–1.

Bayfield, R. F. and E. R. Cole, (1980). Colorimetric estimation of vitamin A with trichloroacetic acid. *Methods Enzymol.*, *67*: 180–195

Burton, G. W. and E. H. de Vane, (1953). Estimating heritability in tall fiscue (*Festuca arundinacea*) from replicated clonal material. *Agron. J.*, *45*(10): 478–481.

Chopra, R. N., S. L. Nayar and I. C. Chopra, (1956). Glossary of Indian medicinal plants. CSIR, New Delhi, India, pp. 186–187.

Dikshit, K. R. and J. K. Dikshit, (2014). North-east India: Land, people and economy, Dordrecht, *Springer*. p. 9.

Haddad, G. O. (1968). New yield data for passion fruit parchita (*P. edulis* forma *flavicarpa*) in different stocking densities and trellis heights. *Agron. Trop., 18*: 387–392.

Hedge, J. E. and B. T. Hofreiter, (1962). Determination of reducing sugars and carbohydrates. In: Methods in carbohydrate chemistry, Whistler, R.L. and Be Miller, J.N. ed. Academic Press, New York, pp. 380–394.

Jamir, T. T., Sharma, H. K. and Dolui, A. K. (1999). Folklore medicinal plants of Nagaland, India. *Fitoterapia*, *70*: 395–401.

Joy, P. P. (2010). Passion fruit (*P. edulis* Sims): *P*.ceae. Technical Bulletin, Pineapple Research Station, Kerala Agricultural University, Vazhakulam, Muvattupuzha, Ernakulam, District, Kerala, India.

Kirtikar, K. R. and B. D. Basu, (1975). Indian Medicinal Plants. Periodical Experts, Dehradun, India, p. 1103.

Kumar, S. (2002). Studies on effect of VAM and growth regulators on *Gladiolus grandiflorus* L. cv. Jessica, Ph.D. Thesis, Hissar, Haryana.

Martins, M. R., J. C. de Oliveira, A. O. Di Mauro and P. C. da Silva. (2003). Evaluation of passion fruit populations (*P. alata* curtis) obtained from open pollination. *Rev. Bras. Frutic*., *25*: 111–114.

Mowrey, D. (1993). Herbal tonic therapies, Keats Publishing Incorporation, New Canaan. p. 16.

Negreiros, J. R., V. da Saavares, C.H. Bruckner, M.A. Morgado and C.D. Cruz, (2007). Relationship between physical characteristics and yield of yellow passion fruit pulp. *Magazine Brasileira de Fruticultura Jaboticabal*, *3*: 546–559.

Panse, V. S. (1957). Genetics of quantitative characters in relation to plant breeding. *Indian J. Genet*., *17*: 318–328.

Ranganna, S. (1986). Handbook of analysis and quality control for fruit and vegetable products. Tata McGraw-Hill Publication, New Delhi, India.

Rao, T. M., Tripathi, P. C., Karunakaran, G. Sakthivel, T., Sankar, V. and Kumar, R.S. (2014). Passion fruit cultivation in India. Technical bulletin No. 3, Central Horticultural Experiment Station, ICAR-Indian Institute of Horticultural Research (IIHR), Chettalli-571248, Kodagu, Karnataka, India, p. 17.

Santos, C. L., A. P. Viana, M. S. M. D. Freitas, A. J. C. D. Carvalho and D. L. Rodrigues, (2017). Relationship between yield and fruit quality of passion fruit progenies under different nutritional levels. *Revista Brasileira de Fruticultura*, *39*: 2– e691.

Singh, S. R., A. K. Phurailatpam, L. Wangchu, P. Ngangbam and T. M. Chanu, (2014). Traditional medicinal knowledge of underutilized minor fruits as medicine in Manipur. *Int. J. Agric. Sci.*, *4*: 241–247.

Tripathi, P. C., G. Karunakaran, T. Sakthivel, V. Sankar and R. Senthilkumar, (2014). Cultivation of Passion fruit. Central Horticultural Experiment Station Indian Institute of Horticultural Research Chettalli-571 248, Kodagu, Karnataka.

Vijay, D. T. and S. B. Rajendra, (2014). Estimation of total phenol, tannin, alkaloid and flavonoid in Hibiscus tiliaceus L. wood extracts. *Int. J. Pharmacog. Phytochem. 2*: 41–47.

Weber, D., J. C. Fachinello and A. Saavedra del, 2014. Correlations between production and quality characteristics of the yellow passion fruit selection' Ovalado Grande'in southern Brazil. In: 19th International Horticultural Congress on Horticulture: Sustaining Lives, Livelihoods and Landscapes, pp. 17–24.

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