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Diversity in Morphological Characteristics in Litchi (*litchi chinensis* sonn.) Accessions at Northern hill Region of Chhattisgarh

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Abstract
The present investigation was undertaken in genetic diversity of morphological characteristics of twenty genotypes accessions of litchi growing area under the agro-climatic zone Northern hill region of Chhattisgarh in the horticultural orchard of Raj Mohini Devi college of Agriculture and research station Ambikapur. An analysis of the data for various characters like Tree height, Tree canopy, Tree girth, Leaf length, Leaf width, Number of fruits per panicle, Fruit colour, Fruit size, Fruit weight, Fruit pulp weight, Flower colour, Panicle length, in fruits and total soluble solid were taken into account on the basis of present experimental findings Kasbah (leaflet blade length, width and length), Desi (Rachis length), China (number of leaflet/leaf), Green (leaf area) and Pickling (shoot length) were found significantly higher among thirty one accessions. The cultivars differed in some of the morphological characteristics. The differences were probably due to their genetic makeup as well as due to the influence of climatic factors of that particular region.

Keywords: Litchi Chinensis, diversity, morphological characters of leaf, Tree, panicle, colour, width, length and TSS, accessions.

1. Introduction
Litchi (*Litchi chinensis* Sonn.) is the one of the most important sub-tropical fruit belongs to the family *Sapindaceae*. It is native to southern China and introduced in India during the end of the 17th century. The top five litchi producing countries are China, India, Taiwan, Thailand, and Vietnam. India ranked second after China in the area as well production. India and China account for 91 percent of the world's litchi production.

India produced total 26,509 million metric tonnes with an area of 83 thousand hectares and average productivity of 7.00 metric tonnes per hectare (Anonymous, 2013) [2]. Litchi requires precise climatic conditions, there are only a few states namely, Bihar, West Bengal, Uttaranchal, Uttar Pradesh, Himachal Pradesh, Assam, Tripura, Punjab and Jharkhand growing the fruits commercially.

It is an extremely environmental sensitive fruit crop that requires specific climatic conditions, growing best in regions with short, dry, and cool,but frost-free winters (daily maximums below 20–22 ^{0}C), and summers that are long and hot (daily maximums above 25 ^{0}C) with high rainfall (1200 mm) and high humidity (Singh, 2002) [28]. Bihar has monopoly in production and north Bihar particularly Muzaffarpur shares 85 per cent of the total area under litchi cultivation, where soil and climatic conditions are very congenial for its growth and fruiting.

The environmental conditions of Chhattisgarh hills is also very suitable for the production as nearly 4,469 hectares area with production of 27,077 metric tonnes and average productivity of 6.06 metric tonnes per hectare, which indicates encouraging possibilities of production for this crop (Anonymous, 2012) [1]. Litchi is a highly priced, popular and major table fruit in Chhattisgarh. It comes to market in the months of May-June when the market is full of other fresh fruits, particularly mango and jackfruit. But in spite of the availability of different types of fruit in the market the demand for fresh litchi is always very high due to its unique taste, flavor and color.

Litchi is mostly consumed as a table fruit but is also preserved and canned. 100 gm of fresh edible portion contain 63-64 calories, 81.9-84.83% water, 0.68-1.0gm protein, 0.3-0.58gm fat, 13.31-16.4gm carbohydrates, 0.23-0.40gm fiber, 0.37-0.50gm ash, 8-10 mg calcium, 30-42

mg phosphorus, 0.40 mg iron, 3mg sodium, 170 mg potassium, 28 mg thiamine, 0.40 mg nicotinic acid, 0.05 mg riboflavin and 24-60 mg ascorbic acid (Mondal and Amin, 1990., Bose and Mitra 1990; Scanlan,1995) [17, 4, 24].The sugar content of litchi ranging between 10 and 22 per cent owing to variation in cultivar and climatic conditions.

Litchi is affected by numbers of factors. Among the factors insect pests and post-harvest losses are a major constraint. It has been infested by numbers of insect pest (Hameed *et al.,* 2001) [8]. There are more than 54 insect and mite pests known to attack litchi tree and its fruits but only a few, namely litchi mite (*Aceria litchii* Keifer), litchi fruit borer (*Conopomorpha cramerella* Snellen), litchi leaf roller (*Dudua aprobola* Meyrick) and bark eating caterpillar, *Indarbella* spp. cause serious damage to the crop (Lall and Sharma, 1978, Sharma, 1985, Hameed *et al*., 1999 and Mukherjee *et al.,* 2007) [16, 25, 18]

2. Materials and methods

All the twenty litchi genotypes were examined for the study of morphological traits related with tolerance in litchi genotypes against fruit borer, *Conopomorpha sp*.at horticulture orchard of the RMD College of Agriculture and Research Station, Ambikapur Surguja (CG) during January to December 2015 and January to December 2016.

The observation of twenty genotypes replicated in thrice. on each tree, morphological characters *viz.* tree height, tree canopy, tree girth, leaf length, leaf width, panicle length, flower colour, number of fruit per panicle, fruit colour, fruits size, weight of fruit, weight of pulp and quantity of total soluble solid (TSS) were recorded.

3. Results and discussion

On the basis of screening of twenty litchi genotypes against fruit borer infestation, it was observed that the genotype Rose Scented showed minimum per cent age fruit damage followed by Ambika litchi 1. These twenty genotypes were further analyzed to look out for the resistance mechanism involved. Under these, various morphological parameters *viz.*tree height, tree canopy, tree girth, leaf length, leaf width, panicle length, flower colour, number of fruit per panicle, fruit colour, fruits size, weight of fruit, weight of pulp and quantity of total soluble solid (TSS) on the fruits were selected and correlated with per centage fruit damage due to fruit borer. The details are as follows-

Tree height

Tree height (mean of two years 2015 and 2016) indicated that the mean tree height showed significant differences among the tested genotype which varied from 4.00 meter (Surguja selection-6, Surguja selection-7, Surguja selection-8 and late large red) to 7.33 meter (Purvi).The y = percent fruit damage by fruit borer, *Conopomorpha sinensis* was correlated with x = tree height. There was negative trend between per cent age fruit damage and tree height with 'r' value of -0.37 found at 5 per cent level of significance. The correlation showed no relationship (non preference type resistance mechanism) between tree height and per cent fruit damage by fruit borer, *Conopomorpha sinensis*.

Tree canopy

Tree canopy (mean of two year 2015 and 2016) indicated that mean tree canopy north to south and east to west direction showed significant differences among the tested genotype which varied from 4.00 to 9.00 meter and 5.00 to 10.33 meter respectively. The y =per cent fruit damage by fruit borer, *Conopomorpha sp*. was correlated with x = tree canopy. Tree canopy of tested genotypes were showed no significant role of preference or non preference of resistance mechanism for fruit damage by fruit borer, *C. sp*. The correlation 'r' value 0.06 was found at 5 per cent level of significance. Thus, tree canopy did not offer resistance/susceptibility to tested litchi genotypes against fruit borer.

Tree girth

Tree girth (mean of two year 2015 and 2016) indicated that mean tree girth showed significant differences among the tested genotype which varied from 5.66 to 84.00 meter. The y =percent fruit damage by fruit borer, *Conopomorpha. sp*. was correlated with x = tree girth. Tree girth of tested genotypes also showed no significant role of preference or non preference of resistance mechanism for fruit damage by fruit borer, *C. sp*. The correlation 'r'value - 0.49 was found at 5 per cent level of significance. Thus, tree girth did not offer resistance/susceptibility of tested litchi genotypes against fruit borer.

Leaf length

Leaf length (mean of two year 2015 and 2016) indicated that mean leaf length showed significant differences among the tested genotype which varied from 3.33 to 6.66 cm. The y =percent fruit damage by fruit borer, *Conopomorpha. sp*. was correlated with x = leaf length. There was negative trend between per cent age fruit damage and leaf length with 'r' value of - 0.32 found at 5 per cent level of significance. The correlation showed no relationship (non preference type resistance mechanism) between leaf length and per cent fruit damage by fruit borer, *C. sp*.

Leaf width

Leaf width (mean of two year 2015 and 2016) indicated that mean leaf width showed significant differences among the tested genotype which varied from 1.83 to 3.31 cm. The y =percent fruit damage by fruit borer, *Conopomorpha sp*. was correlated with x = leaf width. There was positive significant correlation between per cent age fruit damage and leaf width with 'r' value of 0.62 found at 5 per cent level of significance. These findings justifies that the increase in leaf width is favorable for the fruit borers and the fruit infestation decreased with decrease in leaf width. Thus, the leaf width played an important role in tested litchi genotypes against fruit borer infestation and making plant resistance.

Number of fruit per panicle

Number of fruit per panicle (mean of two years 2015 and 2016) indicated that mean number of fruit per panicle showed significant differences among the tested genotypes which varied from 12.00 to 21.33 fruits per panicle. The y =percent fruit damage by fruit borer, *Conopomorpha sp*. was correlated with x = number of fruit per panicle. There was negative significant correlation between per cent age fruit damage and number of fruit per panicle with 'r' value of - 0.65 found at 5 per cent level of significance. These findings justifies that the increase in number of fruit per panicle is unfavorable for the fruit borers and the fruit infestation decreased with increase in number of fruit per panicle. Thus, the number of fruits per panicle played an important role in tested litchi genotypes against fruit borer infestation and making plant resistant.

Fruit colour

Fruit colour of litchi genotypes was observed by visual observation. They were grouped into four groups i.e. rose red, pinkish red, red and golden red yellow. Out of the twenty genotypes six had rose red colour, eleven had red colour, two had golden red colour and rest one genotypes *viz.* seed less-2 pinkish red. There was no relation between fruit colour of litchi genotypes for resistance/susceptibility against fruit borer found.

Fruit size

Fruit size (mean of two year 2015 and 2016) indicated that mean fruit size showed significant differences among the tested genotypes which varied from 2.30 to 2.93 cm. The y =per cent fruit damage by fruit borer, *Conopomorpha sp*. was correlated with x = fruit size. There was negative non significant correlation between per cent age fruit damage and fruit size with 'r' value of -0.12 found at 5 per cent level of significance. The correlation showed no relationship (non preference type resistance mechanism) between fruit size and per cent fruit damage by fruit borer, *Conopomorpha sp*.

Fruit Weight

Fruit weight (mean of two year 2015 and 2016) indicated that mean fruit weight showed significant differences among the tested genotypes which varied from 8.59 to 19.51 g. The y =per cent fruit damage by fruit borer, *Conopomorpha sp*. was correlated with x = fruit weight. There was negative non significant correlation between per cent age fruit damage and fruit weight with 'r' value of - 0.28 found at 5 per cent level of significance.

Fruit pulp weight

Fruit pulp weight (mean of two years 2015 and 2016) indicated that mean fruit pulp weight showed significant differences among the tested genotypes which varied from 3.04 to 10.74 g. The y =per cent fruit damage by fruit borer, *Conopomorpha sp*. was correlated with x = fruit pulp weight. There was negative non significant correlation between per cent age fruit damage and fruit pulp weight with 'r' value of - 0.44 at 5 per cent level of significance.

Flower Colour

Flower colour of litchi genotypes was observed by visual observation. There was only one colour i.e. and in all of the twenty genotypes yellow colour was yellow in colour. No relation between flower colours of litchi genotypes for resistance/susceptibility against fruit borer was found.

Panicle length

Mean panicle length (mean of two years 2015 and 2016) indicated that length showed significant differences among the tested genotype which varied from 2.00 to 3.66cm. They =percent fruit damage by fruit borer, *Conopomorpha sp*. was correlated with x = panicle length. Which was negative and non significant with 'r' value of - 0.23at 5 per cent level of significance. Thus the correlation showed no significant relationship (non preference type resistance mechanism) between panicle length and per cent fruit damage by fruit borer, *C. sp*.

TSS (Total soluble solid)

Mean total soluble solid (TSS) (mean of two years 2015 and 2016) showed significant differences among the tested genotype which varied from 17.84 to 21.70 percent. The percent fruit damage by fruit borer, *Conopomorpha sp*. was correlated with x =TSS, which was found to be negative and significant with 'r' value of - 0.52 found at 5 per cent level of significance. These findings justifies that the increase in TSS was a favorable for the fruit borers and the fruit infestation decreased with increase in TSS content. Thus, the TSS played an important role in tested litchi genotypes against fruit borer infestation in offering plant resistance.

All the morphological parameters of twenty litchi genotypes tested against fruit borer infestation, revealed that leaf width, number of fruits per panicle and total soluble solid significantly played an important role in tolerance against fruit borer infestation. Increase in leaf width was favorable for the fruit borers and the fruit infestation decreased with decrease in leaf width. Increase in number of fruit per panicle and TSS was non favorable for the fruit borers and the fruit infestation decreased with increase in number of fruit per panicle and TSS. Thus, the number of fruit per panicle and TSS played an important role in the tested litchi genotypes against fruit borer infestation and making plant tolerant up to some extent.

Dissimilar trend of result was obtained by Faruck (2005) [6]where litchi fruit borer infestation was positively correlated with fruit length, fruit width, and weight of fruit skin, flesh, seed and total fruit, whereas negative co-relation was observed with number of size and weight of fruits in the present studies. Khurshid *et al.* (2004) [10] reported that the genetic diversity in morphological characteristics of four cultivar of litchi i.e., Bedana, Bombay, Calcuttia and Gola growing under the agro-climatic conditions of Multan and various characteristics like tree height, canopy spread, tree shape, foliage texture and colour, leaf length, width, shape and orientation, internodal distance, number of leaf lets per leaf, number of leaves per flush, flush colour, panicle length, number of anthers and carpels per flower, filament and style size, fruit colour and size were taken into count and found that the cultivars differed in some of the morphological characteristics, which is in agreement with the present studies

Table 1: Morphological traits of different litchi genotypes at Ambikapur during the crop growth years 2015- 2016

S.N.	Genotypes	Tree				Leaf		Fruit				
		Height (m)	Canopy (m)		Girth (cm)	Length (cm)	Width (cm)	No. of fruit/ panicle	Colour	Size (cm)	Weight (g)	Wt. of pulp (g)
			N-S	E-W								
1	Ambika litchi-1	7.23	7.33	7.00	76.00	5.66	2.16	22.33	Rose Red	2.60	11.78	5.85
2	Seedless-2	7.23	8.00	8.33	82.66	6.66	2.16	20.33	Pinkish Red	2.70	13.03	6.09
3	Kalkattia	5.73	6.33	7.56	82.66	4.66	2.10	16.20	Red	2.66	12.82	5.88
4	Damdam	6.66	7.36	8.33	78.66	6.33	1.83	16.66	Rose Red	2.76	15.71	10.01
5	Rose Scented	6.36	8.00	7.70	84.00	6.33	2.00	21.33	Rose Red	2.60	15.61	10.26
6	China	5.33	6.30	6.00	63.33	5.00	2.00	16.33	Rose red	2.76	12.61	4.84
7	Surguja selection-2	4.66	9.00	8.00	62.00	4.33	2.00	16.66	Red	2.93	11.88	3.91
8	Seedless-1	6.00	9.00	6.33	50.66	4.00	2.00	15.00	Golden Red	2.40	14.51	9.43

9	Dehradoon	5.66	7.66	5.66	75.33	5.66	2.00	15.00	Red	2.66	16.50	9.83
10	Shahi	7.00	7.66	5.66	77.66	5.00	2.27	15.33	Red	2.80	19.51	10.74
11	Early Bedana	5.00	9.00	10.33	61.66	5.33	3.31	14.33	Golden Red	2.63	08.59	5.10
12	Bombaya	6.33	7.33	8.33	67.66	3.33	2.29	13.66	Red	2.63	15.26	6.17
13	Purvi	7.33	5.00	9.66	66.66	4.33	2.75	12.00	Red	2.53	11.00	3.77
14	Kasaba	5.00	4.00	9.33	51.00	6.00	2.33	14.00	Rose Red	2.30	13.78	3.95
15	Surguja selection-6	4.00	8.00	7.00	59.33	5.33	2.34	15.33	Red	2.43	09.46	3.50
16	Surguja selection-7	4.00	6.00	5.00	60.00	3.33	2.18	15.66	Red	2.33	09.54	3.33
17	Surguja selection-8	4.00	6.00	5.00	60.00	5.00	2.36	13.33	Red	2.43	09.89	4.91
18	Surguja selection-9	4.66	7.66	10.33	60.00	5.00	2.35	14.33	Red	2.60	13.04	5.37
19	Surguja selection-5	4.66	6.33	7.66	52.66	5.00	2.82	17.33	Red	2.66	09.86	3.88
20	Late large red	4.00	6.66	7.66	57.66	4.66	2.49	15.33	Rose Red	2.50	09.49	3.04
SE(m)		0.55	0.56	0.55	6.06	0.14	0.12	1.38		0.06	0.42	0.44
C.D.		1.58	1.60	1.56	17.36	0.41	0.34	3.94		0.17	1.21	1.25

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Genotypes	Morphological traits			
	Flower colour	Panicle length (cm)	TSS%	No. of spines on litchi fruit
Ambika litchi-1	Yellowish	3.00	20.08	371.33
Seedless-2	Yellowish	2.00	17.84	406.33
Kalkattia	Yellowish	2.70	19.50	423.00
Damdam	Yellowish	2.60	19.71	289.00
Rose Scented	Yellowish	3.40	22.39	342.00
China	Yellowish	3.60	21.02	388.00
Surguja selection-2	Yellowish	3.53	20.50	397.00
Seedless-1	Yellowish	3.66	21.38	364.33
Dehradoon	Yellowish	3.00	21.70	313.33
Shahi	Yellowish	3.36	18.22	367.67
Early Bedana	Yellowish	3.00	19.71	357.67
Bombaya	Yellowish	3.00	18.51	396.00
Purvi	Yellowish	3.00	17.86	336.33
Kasaba	Yellowish	2.80	18.18	369.00
Surguja selection-6	Yellowish	2.70	19.39	312.33
Surguja selection-7	Yellowish	3.36	19.68	400.33
Surguja selection-8	Yellowish	2.66	21.05	394.00
Surguja selection-9	Yellowish	2.66	20.10	386.33
Surguja selection-5	Yellowish	2.86	19.43	391.67
Late large red	Yellowish	3.60	20.05	319.33
SE(m)		0.17	0.56	0.12
C.D.		0.48	1.60	0.34

Table 2: Correlation between morphological traits and percentage fruit infestation by fruit borer, *Conopomorpha sp*. on different litchi genotypes at Ambikapur during the crop growth years 2015- 2016

S. No.	Morphological traits	Correlation coefficient (r)
1	Tree height	-0.37
2	Tree Canopy	0.06
3	Tree Girth	-0.49
4	Leaf Length	-0.32
5	Leaf Width	0.62*
6	No. of Fruit	-0.65*
7	Size of fruit	-0.12
8	Weight of fruit	-0.28
9	Weight of pulp	-0.44
10	Panicle length	-0.23
11	TSS (%)	-0.52*
12	No. of spines on litchi fruit	-0.04

*****: Significant (5%)
******: Highly significant (1%)

Conclusions

Under these, various morphological parameters *viz*. tree height, tree canopy, tree girth, leaf length, leaf width, panicle length, flower colour, number of fruit per panicle, fruit colour, fruits size, weight of fruit, weight of pulp, no of spines in fruits and quantity of total soluble solid (TSS) were selected and correlated with percentage fruit damage due to fruit borer. All the morphological parameters of twenty litchi genotypes were tested for tolerance against fruit borer infestation, it was observed that leaf width, number of fruits per panicle and total soluble solid (TSS) significantly played an important role of tolerance against fruit borer infestation.

Increase in leaf width was favorable for the fruit borers and the fruit infestation decreased with a decrease in leaf width. Increase in the number of fruit per panicle and TSS was found non favorable for the fruit borers and the fruit infestation decreased with increase in the number of fruit per panicle and total soluble solid (TSS). Thus, the number of fruit per panicle and TSS played an important role in tested litchi genotypes against fruit borer infestation offering plant resistance.

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