

**ASSESSMENT OF GENETIC VARIABILITY IN LOCAL  
COLLECTIONS OF CUCUMBER (*Cucumis sativus* L.)  
GENOTYPES FOR PRODUCTIVITY TRAITS**

**MEENAKSHI S. DODDAMANI**



**DEPARTMENT OF BIOTECHNOLOGY AND CROP IMPROVEMENT  
KITUR RANI CHANNAMMA COLLEGE OF HORTICULTURE,  
ARABHAVI – 591 218  
UNIVERSITY OF HORTICULTURAL SCIENCES,  
BAGALKOT – 587 102**

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**ASSESSMENT OF GENETIC VARIABILITY IN LOCAL  
COLLECTIONS OF CUCUMBER (*Cucumis sativus* L.)  
GENOTYPES FOR PRODUCTIVITY TRAITS**

*Thesis submitted to the  
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**MEENAKSHI S. DODDAMANI  
ID No.UHS16PGM702**

**DEPARTMENT OF BIOTECHNOLOGY AND CROP IMPROVEMENT  
KITTUR RANI CHANNAMMA COLLEGE OF HORTICULTURE,  
ARABHAVI – 591 218  
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**UNIVERSITY OF HORTICULTURAL SCIENCES, BAGALKOT  
KITUR RANI CHANNAMMA COLLEGE OF HORTICULTURE,  
ARABHAVI  
DEPARTMENT OF BIOTECHNOLOGY AND CROP  
IMPROVEMENT**

**CERTIFICATE**

This is to certify that the thesis entitled “**ASSESSMENT OF GENETIC VARIABILITY IN LOCAL COLLECTIONS OF CUCUMBER (*Cucumis sativus* L.) GENOTYPES FOR PRODUCTIVITY TRAITS**” submitted by **MEENAKSHI S DODDAMANI**, Id No, **UHS16PGM702** for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **BIOTECHNOLOGY AND CROP IMPROVEMENT** to the University of Horticultural Sciences, Bagalkot is a record of research carried out by her during the period of her study at University of Horticultural Sciences, Bagalkot under my guidance and supervision and the thesis has not previously been formed the basis of the award of any degree, diploma, associateship, fellowship or other similar titles.

Place: Arabhavi

Date: July, 2018

**(SATISH D.)  
MAJOR ADVISOR**

**Approved by**

**Major Advisor:**

\_\_\_\_\_  
**(SATISH D.)**

**Members:** 1.

\_\_\_\_\_  
**(SEETHARAMU, G. K)**

2.

\_\_\_\_\_  
**(TATAGAR, M. H)**

3.

\_\_\_\_\_  
**(SANDHYARANI NISHANI)**

4.

\_\_\_\_\_  
**(DILEEPKUMAR A. MASUTHI)**

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*Needless to say, errors and omissions are mine.*

**ARABHAVI**

**September, 2018**

**(MEENAKSHI, S. DODDAMANI)**

***Affectionately Dedicated  
to  
My Beloved Parents,  
Brother and Sister***

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## LIST OF ABBREVIATIONS

cm	centimeter
m	meters
G	grams
kg	Kilo grams
GV	Genetic variability
PV	Phenotypic variability
GCV	Genotypic coefficient of variation
PCV	Phenotypic coefficient of variation
GA	Genetic advance
GAM	Genetic advance per cent over mean
$h^2$	Heritability
RCBD	Randomized complete block design
CV	Coefficient of variance
CD	Critical difference
%	Per cent
Fig	Figure
<i>viz.</i>	videlicet (namely)
KRCCH-CC	Kittur Rani Channamma College of Horticulture, Cucumber Collections.

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# 1. INTRODUCTION

Cucumber (*Cucumis sativus* L.) is one of the most popular vegetable of family cucurbitaceae with chromosome number of  $2n=14$  and comprises of 117 genera and 825 species in warmer parts of the world (Gopalakrishnan, 2007). It is an ideal summer vegetable crop chiefly grown for its edible tender fruits.

The genus *Cucumis* consists about 30 species distributed over two distinct geographical areas, south east of Himalayan group and African group. According to De Condole (1982), cucumber is indigenous to India and seems to have spread eastwards to China and westwards to Asia Minor, North Africa and Southern Europe. It has been cultivated in India for more than 3000 years and records indicate that it was used for food by ancient Egyptians, Greeks and Romans. It was grown in France in 9<sup>th</sup> century and in England during 14<sup>th</sup> century. Columbus was supposed to have brought cucumber to America. China is considered as secondary centre of diversity, where it occupies second largest area among vegetables after Chinese cabbage. It was cultivated almost throughout in the middle ages and was common in France in 9<sup>th</sup> century, in England in 1327 A.D (Thamburaj *et al.*, 2014).

Cucumber is nutritionally very rich in vitamins and minerals. It has property of cooling effect and in the eastern countries; fruits are often used as cooling vegetable. The fruit of cucumber are eaten as salad, desert fruit, pickles in immature stage and as a cooked vegetable. They are mainly used as refreshing material due to their low energy content. One hundred gram of edible cucumber fruit contain 96 g water, 0.6 g protein, 0.1 g fat, 2.2 g carbohydrate, 45 IU vitamin A, 0.03 mg vitamin B1, 0.02 mg vitamin B2, 0.3 mg Niacin, 12 mg vitamin C, 12 mg calcium, 0.3 mg iron, 15 mg magnesium and 24 mg Phosphorus (Alcazar *et al.*, 1983). It is ideal for people suffering from jaundice and allied diseases and also very much useful in preventing constipation. It also acts as an appetizer. Seeds contain oil, which is helpful for brain development and body smoothness. Hence, it is being used in Ayurvedic preparations (Robinson and Decker Walter., 1999). Besides this, the whole fruit is used in cosmetic and soap industries.

Several sex forms occur in cucumber *viz.*, monoecious, gynoecious, andromonoecious and hermaphrodite. Monoecious sex form is a predominant one. It is highly cross pollinated crop due to monoecious and gynoecious sex forms. It prefers warm weather and bright light for its better growth and development. However, it can be grown both in summer and rainy season.

In India, it is cultivated in an area of 74000 ha with annual production of 1142 metric tonnes (Anon., 2017). Karnataka is the largest producer of cucumber with production of 126.90 thousand tonnes with highest area of about 8.14 thousand hectares (Anon., 2017). Haveri, Mandya, Belgaum, Koppal, Hassan and Udupi are the main districts of cultivation. In India, there are many standard varieties and hybrids have been released, but there is thrust to increase the production to meet the growing population of India. To achieve this, we need to overcome major constraints like pest and disease problems, develop location specific varieties having desirable horticultural and quality traits, and to make available their seeds to the farmers at a reasonable price.

Germplasm evaluation and characterization for economically important traits are prerequisite for genetic improvement of crop. Because of the genetic diversity in cucumber there is opportunity to select superior types and obtain improvement in yield. The presence of variability provides opportunity for improvement of different quantitative and qualitative characters. The study of variability for various characters is pre requisite for a plant breeder to develop a high yielding variety with good quality. It is important to study genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability ( $h^2$ ), genetic advance over mean (GAM), which would help to increase the efficiency of selection. This work can help to reveal information about economically useful genetic variability in cucumber for breeding program.

Cucumber is highly cross pollinated crop and native of India, exhibit considerable variation for different traits, but very meagre work has been done for the improvement of local types. Therefore, evaluating locally adopted cucumber genotypes for commercial cultivation is priority area of research in improving the productivity, uniformity, fruit quality and market acceptance. With this background, it is worthy to take up the present investigation to have desirable horticultural and quality traits.

Keeping the above considerations in view, the present investigation entitled “Assessment of genetic variability in local collections of cucumber (*Cucumis sativus* L.) genotypes for productivity traits” was planned with following objectives.

- To study the genetic variability for growth, quality, yield and earliness in cucumber genotypes
- To study the character association and path analysis among the yield related traits
- Assessment of extent of genetic diversity existing in local cucumber collections
- Identification of superior cucumber genotypes for productivity related traits

## **2. REVIEW OF LITERATURE**

A number of studies have been made with regard to variability of important characters in cucumber. A brief review of literature available on various aspects of the present investigation has been brought out under the following sub-heads:

- 2.1 Genetic Variability
- 2.2 Character association
- 2.3 Path coefficient analysis
- 2.4 Genetic divergence

### **2.1 Genetic variability studies**

Genetic variability is the basis of all crop improvement programmes. Higher the amount of variability in the population, greater is the scope for its improvement by selection. The importance of genetic variability was perceived by Vavilov (1951) for the first time and advocated that wide range of variability provides better scope for selecting a desirable genotype. Knowledge of heritability for different traits seems to be essential for any crop improvement programme because the heritable component is the consequence of genotype and inherited from generation to generation.

Wright (1921) reported that heritability comprised of additive and non-additive components and it is the former, which responds to selection. A thorough knowledge regarding the amount of genetic variability existing for different characters is necessary for initiating any crop improvement programme. Greater the genetic variability in the available germplasm, better will be the chances for selecting superior genotypes (Simmonds, 1962). Hence, an insight into the magnitude of heritable variability present in the gene pool of a crop species is of utmost importance to a plant breeder for starting a judicious plant breeding programme. A review of information pertaining to genetic variability for different characters in cucumber has been presented in below:

**Table 1. Review of literature on mean, range, heritability, GCV, PCV and GAM in cucumber.**

Sl. No.	Character	Range	Mean	GCV (%)	PCV (%)	GAM (%)	h <sup>2</sup> (BS)	References
1	Vine length (cm)	102.30-261.50	179.20	36.60	36.61	75.40	99.97	Ud-Din <i>et al.</i> (2006)
		--	--	44.64	57.11	--	61.11	Afangideh <i>et al.</i> (2007)
		105.79-140.23	122.79	6.10	6.22	12.31	96.00	Hanchinmani <i>et al.</i> (2011)
		120-218	204.54	3.31	3.44	6.56	92.49	Arunkumr <i>et al.</i> (2011)
		118.23-157.53	136.46	--	--	2.55	7.56	Singh <i>et al.</i> (2011)
		--	--	15.91	24.43	21.3	42.40	Veena <i>et al.</i> (2012)
		145-268	206.00	12.81	21.97	15.51	99.60	Yadav <i>et al.</i> (2012)
		267.25-381.25	334.50	--	--	--	--	Golabadi <i>et al.</i> (2013)
		166.52-227.04	185.23	6.33	9.30	8.78	0.46	Ranjan <i>et al.</i> (2015)
		--	143.67	78.29	78.32	231.6	99.91	Chikezie <i>et al.</i> (2016)
		186.06-249.13	205.86	7.17	7.95	13.34	81.44	Rajwat <i>et al.</i> (2017)
		196.67-249.15	--	12.01	12.03	24.57	99.55	Kandaswamy . R. (2017)
		170.33-290.00	199.47	17.46	18.09	34.71	93.1	Monisha <i>et al.</i> (2017)
1.47-3.20(mt)	2.24	16.86	29.99	0.44	31.59	Chandan Singh <i>et al.</i> (2018)		

Sl. No.	Character	Range	Mean	GCV (%)	PCV (%)	GAM (%)	h <sup>2</sup> (BS)	References
2	Number of leaves per vine	--	--	75.31	124.63	--	36.51	Afangideh <i>et al.</i> (2007)
		-	24.81	52.33	52.80	26.51	98.23	Chikezie <i>et al.</i> (2016)
3	Number of branches per vine	4.60-9.60	7.92	6.98	8.74	11.49	63.80	Arunkumr <i>et al.</i> (2011)
		1.50-6.50	3.55	34.04	36.37	65.62	87.60	Hanchinmani <i>et al.</i> (2011)
		1.43-3.20	2.32	18.57	24.99	48.69	99.57	Yadav <i>et al.</i> (2012)
		0.87-3.07	2.66	--	--	--	--	Golabadi <i>et al.</i> (2013)
		-	2.16	83.20	89.65	3.44	86.13	Chikezie <i>et al.</i> (2016)
		7.20-11.26	8.80	13.79	16.29	71.64	24.04	Rajwat <i>et al.</i> (2017)
4	Number of nodes per vine	4.43-12.93	7.63	38.70	39.27	78.50	97.10	Monisha <i>et al.</i> (2017)
		11.00-23.80	20.92	5.67	6.66	9.94	72.43	Arunkumr <i>et al.</i> (2011)
		8.50-17.50	12.01	19.77	20.03	40.21	97.40	Hanchinmani <i>et al.</i> (2011)
		--	--	13.84	15.12	26.11	83.82	Veena <i>et al.</i> (2012)
		14.00-28.00	21.03	22.75	24.14	44.12	88.80	Monisha <i>et al.</i> (2017)

Sl. No.	Character	Range	Mean	GCV (%)	PCV (%)	GAM (%)	h <sup>2</sup> (BS)	References
5	Days to first male flowering	--	--	8.10	8.75	94.57	16.72	Yadav <i>et al.</i> (2012)
		--	--	6.38	6.62	92.96	12.63	Basavarajeshwari <i>et al.</i> (2014)
		-	28.52	17.49	17.81	10.10	96.51	Chikezie <i>et al.</i> (2016)
		30.86-36.46	34.07	5.27	5.45	3.57	93.44	Rajwat <i>et al.</i> (2017)
		30.32-46.68	39.62	8.45	12.13	4.80	48.44	Chandan Singh <i>et al.</i> (2018)
6	Days to first female flowering	-	38.33	13.32	13.72	10.18	93.77	Chikezie <i>et al.</i> (2016)
		35.33-39.86	38.02	2.88	3.75	4.57	59.13	Rajwat <i>et al.</i> (2017)
		33.25-39.25	--	4.99	5.94	6.12	70.72	Kandaswamy . R. (2017)
		40.67-60.33	44.93	12.18	13.96	21.90	76.20	Monisha <i>et al.</i> (2017)
		33.78-53.35	44.66	10.51	12.90	7.80	66.37	Chandan Singh <i>et al.</i> (2018)
7	Node at first male flower	3.67-5.46	4.44	10.11	15.22	13.83	44.11	Rajwat <i>et al.</i> (2017)
		3.33-7.50	5.42	15.21	25.25	1.02	36.29	Chandan Singh <i>et al.</i> (2018)
8	Node at first female flower	2.60-7.75	4.18	26.28	27.59	52.76	90.72	Ud-Din <i>et al.</i> (2006)
		3.35-5.35	4.40	12.76	13.48	24.90	89.70	Hanchinmani <i>et al.</i> (2011)
		8.27-10.13	9.14	--	--	2.51	12.14	Singh <i>et al.</i> (2011)
		4.51-7.60	6.03	12.71	16.21	20.58	56.22	Yadav <i>et al.</i> (2012)
		7.25-11.25	--	11.47	16.28	16.64	49.63	Kandaswamy . R. (2017)
		4.46-6.80	5.36	12.78	15.14	22.21	71.22	Rajwat <i>et al.</i> (2017)
		1.00-3.00	1.76	39.32	41.57	76.70	89.50	Monisha <i>et al.</i> (2017)
		2.33-9.50	7.04	24.07	29.97	2.80	64.54	Chandan Singh <i>et al.</i> (2018)

Sl. No.	Character	Range	Mean	GCV (%)	PCV (%)	GAM (%)	h <sup>2</sup> (BS)	References
9	Number of male flower	155.00-190.00	173.50	5.43	5.58	10.91	94.98	Arunkumr <i>et al.</i> (2011)
10	Number of female flower	--	--	20.92	89.85	--	5.42	Afangideh <i>et al.</i> (2007)
		106.00-200.06	147.91	19.62	20.79	38.14	89.04	Rajwat <i>et al.</i> (2017)
		-	12.50	35.37	35.88	8.98	97.17	Chikezie <i>et al.</i> (2016)
11	Days to 50 per cent flowering	8.25-16.45	12.60	26.54	27.68	5.88	91.92	Ud-Din <i>et al.</i> (2006)
		--	--	29.44	81.31	--	13.11	Afangideh <i>et al.</i> (2007)
		42.00-55.00	46.91	5.21	5.97	9.39	76.32	Arunkumr <i>et al.</i> (2011)
		-	3.56	47.92	49.22	3.42	94.79	Chikezie <i>et al.</i> (2016)
		14.00-28.53	21.28	19.28	21.54	35.56	80.14	Rajwat <i>et al.</i> (2017)

Sl. No.	Character	Range	Mean	GCV (%)	PCV (%)	GAM (%)	h <sup>2</sup> (BS)	References
12	Days to first fruit harvest	54.70-70.80	63.92	10.21	10.43	20.58	95.79	Ud-Din <i>et al.</i> (2006)
		46.50-58.00	54.18	4.77	5.05	9.30	89.40	Hanchinmani <i>et al.</i> (2011)
		40.00-49.00	44.38	4.38	5.63	7.01	60.48	Arunkumr <i>et al.</i> (2011)
		43.24-58.27	50.97	6.54	6.55	13.47	99.74	Yadav <i>et al.</i> (2012)
		--	--	8.26	9.93	14.14	69.20	Kumar <i>et al.</i> (2013)
		45.66-50.53	48.27	3.08	3.26	6.00	89.41	Rajwat <i>et al.</i> (2017)
		51.10-64.10	--	6.89	7.32	13.37	88.64	Kandaswamy . R. (2017)
		69.33-80.67	74.00	5.08	6.67	7.97	58.00	Monisha <i>et al.</i> (2017)
		35.01-55.05	43.72	8.28	15.35	4.02	29.07	Chandan Singh <i>et al.</i> (2018)
13	Total number of fruits per vine	4.25-7.39	5.75	20.39	21.61	39.47	89.00	Ud-Din <i>et al.</i> (2006)
		--	--	53.93	70.48	--	58.56	Afangideh <i>et al.</i> (2007)
		2.50-11.00	5.65	33.10	35.20	64.14	88.50	Hanchinmani <i>et al.</i> (2011)
		8.00-18.00	14.10	17.70	16.31	30.97	84.94	Arunkumr <i>et al.</i> (2011)
		3.40-6.00	4.69	--	--	7.14	15.34	Singh <i>et al.</i> (2011)
		7.84-13.80	10.82	16.12	16.44	32.98	98.66	Yadav <i>et al.</i> (2012)
		--	--	18.00	16.06	29.52	79.60	Kumar <i>et al.</i> (2013)
		3.50-9.10	6.93	27.30	26.80	--	96.41	Basavarajeshwari <i>et al.</i> (2014)
		8.1-13.06	10.04	14.20	15.51	26.79	83.83	Rajwat <i>et al.</i> (2017)
		4.00-8.78	6.15	18.90	28.39	1.59	44.34	Chandan Singh <i>et al.</i> (2018)

Sl. No.	Character	Range	Mean	GCV (%)	PCV (%)	GAM (%)	h <sup>2</sup> (BS)	References
14	Total fruit yield per vine (kg)	0.90-2.75	1.47	37.08	39.50	70.74	87.40	Ud-Din <i>et al.</i> (2006)
		--	--	60.66	85.79	--	50.22	Afangideh <i>et al.</i> (2007)
		4.00-6.6	5.65	9.98	10.36	19.81	92.81	Arunkumr <i>et al.</i> (2011)
		0.45-3.63	1.34	59.19	60.75	118.80	94.90	Hanchinmani <i>et al.</i> (2011)
		1.41-2.59	2.00	18.53	21.52	36.60	99.58	Yadav <i>et al.</i> (2012)
15	Average fruit weight (g)	183.00-290.00	230.68	15.16	15.18	31.19	99.77	Ud-Din <i>et al.</i> (2006)
		275.00-440.00	407.87	3.77	4.12	7.11	83.68	Arunkumr <i>et al.</i> (2011)
		96.70-320.40	214.54	24.27	26.13	46.43	86.30	Hanchinmani <i>et al.</i> (2011)
		97.75-230.43	164.00	11.16	11.26	23.20	99.91	Yadav <i>et al.</i> (2012)
		--	--	25.20	27.19	48.11	85.90	Kumar <i>et al.</i> (2013)
		310.30-479.25	388.73	14.99	15.50	--	93.49	Basavarajeshwari <i>et al.</i> (2014)
		0.48-1.46	--	27.94	29.79	--	88.00	Kandaswamy (2017)
		50.00-157.00	113.73	37.13	37.96	74.83	95.70	Monisha <i>et al.</i> (2017)

Sl. No.	Character	Range	Mean	GCV (%)	PCV (%)	GAM (%)	h <sup>2</sup> (BS)	References
16	Fruit length (cm)	12.45-28.32	18.28	31.27	31.80	63.29	96.68	Ud-Din <i>et al.</i> (2006)
		--	--	17.13	30.73	--	32.89	Afangideh <i>et al.</i> (2007)
		25.50-33.50	29.42	4.10	5.76	6.02	50.72	Arunkumr <i>et al.</i> (2011)
		10.91-35.79	20.32	48.63	29.69	56.88	93.00	Hanchinmani <i>et al.</i> (2011)
		13.78-20.67	16.57	--	--	7.14	24.34	Singh <i>et al.</i> (2011)
		13.80-24.94	19.37	15.02	15.12	30.93	100.00	Yadav <i>et al.</i> (2012)
		12.88-17.27	15.12	--	--	--	--	Golabadi <i>et al.</i> (2013)
		--	--	20.47	21.63	39.92	89.60	Kumar <i>et al.</i> (2013)
		15.16-20.14	17.98	8.28	9.30	--	80.66	Basavarajeshwari <i>et al.</i> (2014)
		--	15.03	25.41	25.88	7.73	96.43	Chikezie <i>et al.</i> (2016)
		12.38-19.33	16.22	11.66	11.92	23.50	95.67	Rajwat <i>et al.</i> (2017)
		25.47-45.53	--	16.43	16.53	33.65	98.80	Kandaswamy . R. (2017)
6.42-23.68	16.24	27.65	30.20	8.47	83.84	Chandan Singh <i>et al.</i> (2018)		
17	Fruit diameter (cm)	3.90-6.45	5.61	16.60	19.21	29.59	74.80	Ud-Din <i>et al.</i> (2006)
		4.20-7.50	6.00	11.6	13.37	20.87	75.73	Arunkumr <i>et al.</i> (2011)
		2.11-5.64	4.03	19.48	20.67	37.84	88.90	Hanchinmani <i>et al.</i> (2011)
		3.07-4.63	4.05	--	--	6.82	24.08	Singh <i>et al.</i> (2011)
		2.80-4.25	3.52	11.34	11.51	22.96	99.98	Yadav <i>et al.</i> (2012)
		2.46-3.07	2.62	--	--	--	--	Golabadi <i>et al.</i> (2013)
		--	15.58	28.49	28.95	9.00	96.81	Chikezie <i>et al.</i> , (2016)
		3.17-4.19	3.62	5.57	10.60	6.03	27.59	Rajwat <i>et al.</i> (2017)
		6.26-15.38	--	26.85	26.87	55.26	99.83	Kandaswamy R. (2017)
		2.44-5.48	3.69	21.22	28.12	1.22	56.96	Chandan Singh <i>et al.</i> (2018)

Sl. No.	Character	Range	Mean	GCV (%)	PCV (%)	GAM (%)	h <sup>2</sup> (BS)	References
18	Flesh thickness (cm)	1.00-1.75	1.26	15.88	13.16	--	75.79	Basavarajeshwari <i>et al.</i> (2014)
19	Number of seeds per fruit	111.02-300.08	174.82	37.22	37.41	--	99.04	Basavarajeshwari <i>et al.</i> (2014)
20	Seed test weight	2.01-2.98	2.49	13.77	15.40	25.14	99.39	Yadav <i>et al.</i> (2012)
		0.57-3.00	1.89	34.28	37.04	--	85.02	Basavarajeshwari <i>et al.</i> (2014)
		15.58-25.30	--	12.17	12.21	24.98	99.33	Kandaswamy R. (2017)
		17.43-30.19	25.95	10.02	17.44	3.08	33.05	Chandan Singh <i>et al.</i> (2018)

**Table 2 : Reviews on genetic divergence in Cucumber**

Sl. No.	No. of Genotypes studied	No. of clusters	Inter cluster distance		Intra cluster distance		Divergence contributing characters	Reference
			Max	Min	Max	Min		
1	31	16	IV and XII	--	II	IV	--	Rao <i>et al.</i> (2003)
2	45	8	IV and V	--	VII	--	--	Chandrashekar <i>et al.</i> (2006)
3	31	7	II and III (4.875)	III and IV (4.221)	II (1.319)	III (0.769)	Fruit length, fruit breadth and fruit weight.	Sharma and Sharma. (2006)
4	58	8	VI and VIII	I and IV	--	--	Fruit length, fruit diameter, Average fruit weight and yield per plant.	Faruk <i>et al.</i> (2010)
5	18	8	VI and VIII (11.24)	III and VI (5.33)	II (5.41)	VIII (0.00)	Fruits per vine and fruit length	Gaikwad <i>et al.</i> (2011)
6	45	8	IV and V (2626.05)	III and IV (160.55)	VII (196.55)	IV (62.71)	--	Hanchinmani and patil. (2011)

**Table 2: Continued..**

Sl. No.	No. of Genotypes studied	No. of clusters	Inter cluster distance		Intra cluster distance		Divergence contributing characters	Reference
			Max	Min	Max	Min		
7	20	4	IV	--	I and II	--	--	Maryam <i>et al.</i> (2012)
8	22	4	II and III (27.666)	I and IV (6.865)	III (1.284)	IV (0.707)	--	Afroz <i>et al.</i> (2013)
9	30	4	II and III	I and III	IV and I	II and III	Fruits per plant and fruit length	Kumar <i>et al.</i> (2013)
10	7	3	I and II (4.078)	I and III (1.011)	I (0.165)	II (0.00)	--	Hasan <i>et al.</i> (2015)
11	16	5	V	--	--	--	--	Chikezie <i>et al.</i> (2016)
12	46	7	IV and VII (25.49)	III and VI (7.32)	IV (8.81)	III and VII (0.000)	--	Chandan <i>et al.</i> (2017)

*Table 2. Continued..*

Sl. No.	No. of Genotypes studied	No. of clusters	Inter cluster distance		Intra cluster distance		Divergence contributing characters	Reference
			Max	Min	Max	Min		
13	56	10	IV and VIII	I and V	VIII	IX and X	Fruit yield per ha, average fruit weight, number of fruits per vine, number of branches per vine, fruit length, fruit width, number of leaves per vine and days to first harvest	Rai <i>et al.</i> (2018)
14	13	4	II and IV	I and II	II	I	Number of fruits per vine, average fruit weight, fruit length, fruit diameter, number of leaves per vine and days to first harvest	Shah <i>et al.</i> (2018)

## 2.2 Character association

Yield is a complex character and is governed by polygenic system. Moreover, it is highly influenced by environmental fluctuations. The correlation study indicates the degree of inter relationship of plant characters for improvement of yield as well as important quality parameters in any breeding programme. It measures the degree of association either in positive or in negative direction. Correlation among traits and with yield is important in indirect selection of genotypes for yield improvement (Machikowa and Laosuwan, 2011). Significant and positive correlation between two characters suggests that these characters can be improved simultaneously in a selection programme (Nwofia *et al.* 2015) and selection for one will translate to selection and improvement of the other (Fayeun *et al.*, 2012).

Phenotypic correlation is the observable correlation between two variables, which includes both genotypic and environmental effects. Genotypic correlation on the other hand, is the inherent association between two variables and it may be due to pleiotropic action of genes or linkage or both. Environmental correlation arises entirely due to environmental effects.

The studies on correlation provide an estimate of association between the various characters. The estimates of correlation between the various characters in a crop are of utmost importance in an efficient breeding programme. The data available to the plant breeder on two or more plant characteristics of a sample or a group of strains of a particular crop help immensely in estimating the degree of association among them. The degree of relationship is generally measured in terms of statistical correlation coefficient, which varies from  $-1$  to  $+1$ .

Saikia *et al.* (1995) studied correlation in eight genotypes of cucumber and observed that yield per plant had strong positive association with vine length, number of primary branches per plant, leaf area, fruiting percentage, number of fruits per plant, fruit weight and fruit length, at both genotypic and phenotypic levels.

Correlation study in twenty six lines of cucumber carried out by Singh (1997) revealed significant positive correlations of days to first female flower anthesis, sex ratio, fruit length, fruit diameter, thousand seed weight and vine length with fruit weight. Number of fruits per plant also showed significant and positive correlation with fruit yield per plant whereas, the traits like node number bearing first female flower showed negative and significant correlation with fruit yield per plant. Genotypic correlation coefficients were higher in magnitude than phenotypic correlation coefficients for all the traits studied.

Tripathi (1997) carried out the inter relationship study among different horticultural traits in cucumber and found that fruit yield per plot had positive and significant correlation with number of fruits per plant, fruit weight, fruit length at genotypic level and with number of fruits per plant at phenotypic level. Fruit yield per plant had positive and significant correlation with number of fruits per plant, fruit length and fruit weight.

Wu *et al.* (1997) studied four selected inbred lines of cucumber to find out the genetic correlation of seven agronomic characters and revealed that number of fruits per plant, average fruit weight, fruiting rate and leaf area were positively related to yield, whereas days to flowering and vine length were negatively correlated with yield.

Correlation analysis was carried out by Meng *et al.* (1999) in eight selected gynocious inbred lines. Results revealed that yield had positive genetic correlation with single fruit weight, number of fruits per plant, leaf area and vine length. Whereas, no significant genetic correlation was found between yield and number of primary branches per plant.

Ram *et al.* (2001) recorded that biological yield per plant had positive and significant correlation with yield and number of fruits per plant, whereas it was negatively and significantly correlated with fruit length and diameter.

Highly positive and significant correlation of fruit weight, fruit length and fruit diameter with fruit yield was recorded by Singh *et al.* (2002) while studying ninety eight hybrids of cucumber. The genotypic correlation coefficients were higher than the

phenotypic correlation coefficients for all the traits, which indicated strong inherent association among these traits.

Verma (2003) carried out the correlation studies among different horticultural traits in twenty five genotypes of cucumber and reported that fruit weight had positive and significant correlation with days to first picking, fruit length and fruit yield per plant. Further, days to first female flower anthesis had positive and significant correlations with number of days to first picking at both phenotypic and genotypic levels.

Rao *et al.* (2004) recorded that fruit yield was positively correlated with fruit weight, fruit length and flesh thickness whereas, it was negatively correlated with node number bearing first female flower and days to first female flower anthesis at both genotypic and phenotypic levels.

Correlation study was carried out by Ying *et al.* (2004) in eight selected lines of gynoeocious parthenocarpic cucumber for six agronomic characters. They observed positive genotypic correlation of yield with single fruit weight, number of fruits per plant, leaf area and vine length but no significant genetic correlation was found between yield and number of primary branches per plant.

While studying fifteen cucumber genotypes, Dhiman and Chander (2005) reported that the genotypic correlations were higher than the phenotypic correlations for the characters viz. total number of fruits per plot, fruit length, fruit diameter, days to first male flower anthesis, days to first female flower anthesis, fruit index, number of fruits per hill and fruit yield. Number of fruits per hill expressed high positive correlations with yield and total number of fruits per plot.

Character association study in thirty five diverse genotypes of cucumber was carried out by Kumar (2006). Results revealed that number of fruits per plant, fruit length, fruit diameter and fruit weight had positive and significant correlation with yield per plant, at both genotypic and phenotypic levels whereas, node number bearing first female flower, days to first female flower anthesis and days to marketable maturity showed negative correlation with yield per plant. In all the traits studied, the genotypic

correlation coefficients were slightly higher in magnitude than phenotypic correlation coefficients.

Genetic correlation study was carried out in USA in eleven exotic genotypes from Nigeria and six indigenous cucumber cultivars by Afangideh and Uyoh (2007). Linear correlation analysis showed that number of fruits per plant and length of vine were significantly and positively associated with yield, while days to first female flower anthesis and days to fifty per cent flowering showed negative correlation with yield.

Parihar *et al.* (2007) evaluated forty five F<sub>1</sub> hybrids along with fifteen lines and three testers of cucumber and estimated the phenotypic and genotypic correlation coefficients among the characters observed. Highly significant and positive association was found between fruit yield per plant with number of fruits per plant, average fruit weight, fruit length, vine length and number of nodes per vine. Further, association of vine length with fruit length and number of nodes per vine was positive and significant whereas, fruit length showed significant negative association with days taken to first female flower anthesis.

Kumar *et al.* (2008) studied character association in twenty five diverse cucumber genotypes. The fruit yield per plant was found to be significantly and positively associated with number of primary branches per plant and number of nodes bearing female flowers per plant. Whereas, significant and negative correlation was recorded for yield with hundred seed weight; days to first fruit harvest with fruit length and fruit length with number of nodes bearing female flowers per plant.

Hanchinamani and Patil (2008) evaluated forty five cucumber genotypes and recorded positive and significant association of yield with vine length, internodal distance, number of primary branches per plant, number of nodes per plant, fruit length, fruit diameter, flesh thickness, average fruit weight, number of marketable and unmarketable fruits per plant and total number of fruits per plant. Strong association of these traits revealed that selection based on these traits could ultimately improve yield.

Mohd and Khan (2009) recorded significant positive correlation of fruit yield per plant with fruit weight and number of fruits per plant at both genotypic and phenotypic levels. Further, average fruit weight exhibited significant positive

correlation with fruit length whereas fruit length had negative correlation with number of fruits per plant.

Singh *et al.* (2009) assessed fifteen diverse cucumber genotypes and recorded positive and significant correlation of number of fruits per plant with number of primary branches per plant and fruit weight.

Hossain *et al.* (2010) while studying fifty eight cucumber accessions recorded highly positive and significant correlation of fruit length, fruit diameter, average fruit weight and number of fruits per plant with yield per plant.

Yadav *et al.* (2010) evaluated twenty diverse genotypes of cucumber and recorded correlation of number of days taken for fifty percent germination with number of days to first female flower anthesis. Whereas, correlation of the former was reported to be negative and non significant with seed cavity of fruit, fruit diameter and fruit weight. At the phenotypic level, fruit yield per plant was positively and significantly correlated with number of primary branches per plant, number of fruits per plant, node number bearing first female flower and hundred seed weight. The trait, number of primary branches per plant exhibited highest positive and significant correlation with fruit yield. Whereas, maximum negative association was noted for node number bearing first male flower with fruit yield.

Arunkumar *et al.* (2011) recorded positive significant correlation of number of marketable, unmarketable and total fruits per plant, fruit length, fruit diameter, average fruit weight, number of primary branches per plant, number of nodes per plant and vine length with fruit yield. Whereas, fruit yield showed negative and significant correlation with days to first male and female flowering and days to first harvest.

Correlation study carried out by Kumar *et al.* (2011) in thirty cucumber genotypes revealed that yield had significant positive association with number of marketable fruits per plant, fruit length and fruit diameter, average fruit weight, harvest duration, total soluble solids, seed germination percentage, seed vigour index-I and II, while significant negative correlations were observed with node number bearing first female flower, days to marketable maturity, severity of powdery mildew, anthracnose and angular leaf spot both at phenotypic and genotypic levels.

Bhardwaj and Kumar (2012) carried out correlation analysis between yield and seed characters namely, germination percentage, seedling dry weight, seedling length, vigour index I and II in thirty genotypes of cucumber. Results indicated that dry seedling weight had highest positive and significant correlation with yield, seed vigour index I, seed vigour index II, seedling length and germination percentage.

Ullah *et al.* (2012) evaluated twelve cucumber genotypes and recorded positive significant correlation of fruit diameter, fruit weight, number of leaves per plant, number of fruits per plant, flesh thickness with yield as well as with plant height whereas, days to first harvest showed negative significant correlation with yield, indicating that early maturing varieties have lower yields while late maturing varieties have higher yield. Similarly, there was positive significant relationship between number of leaves per plant and fruit diameter, flesh thickness and fruit weight, plant height and fruit length, leaves per plant and flesh thickness. Whereas, fruit length was negatively and significantly correlated with number of fruits per plant.

Veena *et al.* (2013) studied thirty eight cucumber genotypes and recorded maximum positive correlation of hundred seed weight with yield per plant. Similarly, number of fruits per plant, average fruit weight, fruit length, flesh thickness and seed cavity length had significant positive correlation with yield.

Genetic correlation study in twenty four cucumber genotypes carried out by Khan *et al.* (2015) revealed that yield was positively correlated with fruit length, fruit diameter and vine length. Further, number of fruits per plant had positive and significant association with fruit diameter and vine length.

Correlation study conducted in thirty genotypes by Saheb *et al.* (2017) revealed that yield per plant had positive significant association with average fruit weight, fruit length, diameter, marketable fruits per plant, harvest duration, vine length, primary branches per plant, seed length, hundred seed weight, germination percentage, seed vigour index I and II. Whereas, yield per plant had negative significant correlation with node number bearing first female flower, days to first harvest, total soluble solids and severity of four foliar diseases.

Correlation studies conducted by Shweta *et al.* (2018), revealed that yield per plot had positive and significant association with number of marketable fruits per plant, average fruit weight, harvest duration, seed germination and seed vigour index-I, while significant negative correlations were observed with node number bearing first female flower, days to marketable maturity, anthracnose and angular leaf spot both at phenotypic and genotypic levels.

### **2.3 Path co-efficient analysis**

Path coefficient analysis furnishes a means of measuring the direct and indirect effects of a variable through other variables on the end product. Yield being a complex and polygenic character, direct selection for yield may not be reliable approach because it is highly influenced by environmental factors. Therefore, it becomes essential to identify the component characters, through which yield improvement could be identified. Though correlation gives information about the components of complex character like yield, it will not provide an exact picture of relative importance of the direct and indirect contribution of the component characters to yield.

The technique of path coefficient analysis involves a method of partitioning the total correlation between the dependent variable and the independent component variables *i.e.*, direct effect of independent variable and its indirect effect via third variable on the dependent variable. Thus correlations in combination with path analysis would give a better insight into cause and effect relationship between different pairs of characters. Direct and indirect effects of plant characters on yield in different cucurbits were reviewed briefly here under.

Path coefficient analysis carried out by Saikia *et al.* (1995) revealed that number of fruits per plant had maximum direct effect on yield followed by fruit weight at genotypic level. These traits were considered as important parameters in any selection programme for the yield improvement in cucumber.

Singh (1997) studied path coefficient analysis in twenty six lines of cucumber and reported that number of fruits per plant had highest positive direct effect on fruit yield per plant followed by fruit weight, sex ratio, number of primary branches per plant, flesh to seed cavity ratio and days to first female flower anthesis whereas, highest

positive indirect effect was recorded by number of fruits per plant via harvest duration. Further, days to first harvest, harvest duration and vine length had negative direct effect on fruit yield per plant and number of fruits per plant exhibited negative indirect effect via node number bearing first female flower, sex ratio, vine length, thousand seed weight, rind thickness, days to first female flower appearance and fruit weight.

Path coefficient analysis carried out by Tripathi (1997) showed that number of fruits per vine had the maximum direct and positive effect on yield per vine and also direct positive effect of fruits per vine on yield per vine, but it was low in magnitude as compared to its correlation coefficient. The indirect effect of number of fruits per vine via number of primary branches and vine length was positive, resulting in positive correlation of number of fruits per vine with yield per vine.

Wu *et al.* (1997) evaluated four selected inbred lines of cucumber for seven agronomic characters and path coefficient analysis showed that the yield was affected directly by two agronomic characters *viz.* number of fruits per plant and average fruit weight, whereas yield was indirectly affected by fruiting rate and leaf area of plants.

Meng *et al.* (1999) studied twenty four cucumber cultivars and the study revealed that average fruit weight, number of fruits per plant and fruit length had highest direct effect on early yield. Results also confirmed that days from sowing to female flowering of fifty per cent plants had a negative direct effect on early yield, whereas days from sowing to male flowering of fifty percent plant had a positive direct effect on early yield.

Singh *et al.* (2002) studied path analysis of ninety eight cucumber hybrids, where fruit weight had highest direct effect on fruit yield. Further, fruit length and fruit diameter had also shown direct effect on yield per plot. Whereas, the indirect effect of other characters like fruit length though negligible, was negative, indicating that selection for high yield via fruit length is likely to show reduction in expression of other characters.

Rao *et al.* (2004) studied a total of 31 cucumber genotypes of diverse origin. Path coefficient analysis revealed that characters such as fruit weight, number of fruits per plant, flesh thickness and node number of first female flower are highly associated with fruits per plant.

Ying *et al.* (2004) carried out path analysis in eight selected inbred lines of gynococious parthenocarpic cucumber and recorded that the yield was affected mostly by single fruit weight and fruit number per plant and was indirectly affected by vine length and leaf area.

Dhiman and Chander (2005) carried out path coefficient analysis in fifteen diverse genotypes of cucumber and reported that number of plants per hill and number of plants per plot had maximum direct effect on yield followed by fruit diameter.

Path analysis at phenotypic level carried out by Kumar *et al.* (2008) revealed that higher and positive direct effect of number of fruits per plant followed by number of primary branches per plant and fruit diameter on fruit yield.

Hanchinamani and Patil (2008) recorded high positive direct effect of average fruit weight and total number of fruits per vine on fruit yield per vine through phenotypic path coefficient analysis of forty five genotypes of cucumber. The average fruit weight had the highest positive and direct genotypic effect on fruit yield per vine followed by the total number of fruits per vine. Hence, it would be rewarding to lay stress on these characters in selection programmes for increasing yield.

Singh *et al.* (2009) while studying fifteen diverse genotypes of cucumber, recorded positive direct effect of number of fruits per plant and fruit weight on yield per plant. Therefore, they suggested giving high priority to traits *viz.* number of primary branches per plant, number of fruits per plant and fruit weight while selecting for yield.

Hossain *et al.* (2010) evaluated fifty eight long type cucumber accessions and concluded that fruit length, fruit diameter, average fruit diameter and number of fruits per plant had positive and direct effect on yield per plant.

Arunkumar *et al.* (2011) evaluated six hundred F<sub>2</sub> plants resulting from a cross between Bheemarayana Gudi Local (BGDL) and hot season and noted maximum positive direct effect of total number of fruits, number of primary branches and number of nodes per vine, vine length and days to first male flower anthesis on yield whereas, traits namely, days to first female flower anthesis, days to first fruit harvest, number of marketable fruits per vine, fruit length, fruit diameter and number of unmarketable fruits per vine exerted negative direct effect on yield.

Kumar *et al.* (2011) carried out path analysis in thirty cucumber germplasm and results revealed that average fruit weight had maximum positive direct effect on yield followed by harvest duration, seed vigour index-II, severity of angular leaf spot, anthracnose and powdery mildew, number of marketable fruits per plant and total soluble solids whereas, negative direct effect of fruit length and diameter, seed vigour index-I, days to marketable maturity, seed germination, fruit length and node number bearing first female flower was observed on yield. Hence, they suggested direct selection for fruit weight, harvest duration and number of fruits per plant with minimum disease severity for yield improvement in cucumber.

Veena *et al.* (2013) recorded positive direct effects of seed cavity breadth, flesh thickness, average fruit weight, days to first female flower anthesis and number of fruits per plant on yield per plant whereas, node number bearing first female flower, days to first male flower anthesis, days to first harvest and fruit diameter had negative direct effect on yield.

While studying seven commercial cucumber cultivars of Bangladesh, Hasan *et al.* (2015) reported that number of fruits per plant and fruit weight had maximum positive direct effect on yield.

Path analysis study conducted in thirty cucumber genotypes by Saheb *et al.* (2017) provided a clear picture that, harvest duration had maximum positive direct effect, followed by marketable fruits per plant while, days to first harvest had maximum negative direct effect followed by severity of downy mildew on yield per plant. Further, harvest duration exerted maximum positive indirect effect via marketable fruits per plant whereas; severity of powdery mildew showed maximum negative indirect effect via harvest duration on yield per plant.

Path coefficient analysis study conducted in 30 genotypes by Shweta *et al.* (2018) revealed that severity of powdery mildew had maximum positive direct effect on yield per plot followed by TSS, fruit length, average fruit weight, days to marketable maturity, number of marketable fruits per plant, seed vigour index-I, severity of anthracnose, harvest duration, fruit breadth, severity of angular leaf spot and seed vigour index-II. While, negative direct effect of seed germination and node number bearing first female flower was observed on yield per plot.

## 2.4 Genetic Divergence:

Recent development in quantitative genetics had a substantial contribution in the development of techniques to identify the genetically diverse parents for hybridization aimed at combining desirable genes from several sources. Selection of diverse parents belonging to distant groups leads to a wide spectrum of gene combinations for quantitatively inherited traits. The multivariate analysis using Mahalanobis  $D^2$  statistics is a potent tool to quantify the degree of divergence at genetic level for a rational choice of an ideal parent in a breeding programme.

Edang *et al.* (1971) stated that the clustering pattern could be utilized in choosing parents for cross combinations likely to generate the highest possible variability for various economic characters.

While formulating the cucumber crop improvement programmes, understanding about the nature and degree of genetic divergence available in the germplasm plays a pivotal role. It is well recognised that the use of diverse parents results in superior hybrids and desirable recombinants. Thus the genetic divergence existing in the population helps in selecting suitable parents for hybridization programme.

The review of literature available on genetic divergence studied in cucumber are summarized in the Table 2.

### **3. MATERIAL AND METHODS**

The present investigation on “Assessment of genetic variability in local collections of cucumber (*Cucumis sativus* L.) genotypes for productivity traits” was undertaken during the year 2017-2018 in *kharif* season at Kittur Rani Channamma College of Horticulture, Arabhavi. The details of the experiment, materials used and techniques adopted in the present investigation are presented in this chapter.

#### **3.1 Experimental site**

The present experiment was conducted in the research block of Biotechnology and Crop Improvement of Kittur Rani Channamma College of Horticulture, Arabhavi, Gokak, Belagavi District (Karnataka). Arabhavi is situated in Northern dry zone of Karnataka state at 16° 15' N latitude, 74° 45' E longitude and at an altitude of 612.03 meters above the mean sea level.

Arabhavi, which comes under the Zone-III of region-II among the agro-climatic zones of Karnataka, which has the benefits of both South-West and North-East monsoons. The average rainfall of this area is about 522 mm, distributed over a period of five to six months (June to November) with peak during October. The command area receives water from Ghataprabha left bank canal from mid-July to mid-March. The meteorological data recorded during this period is given in Appendix-I.

#### **3.2 Experimental details**

##### **3.2.1 Experimental materials**

The experimental material comprised of 20 genotypes of local collections of cucumber along with one commercial check. The details of the genotypes used in the present study are presented in Table 1.

##### **3.2.2 Details of the experiment**

Total number of genotypes : 20 (Table 1)

Check : Arabhavi local

Experimental design	: Randomized Complete Block Design (RCBD)
Number of replication	: 2
Spacing	: 1.5 × 1.0 meter

### 3.3 Cultural practices

The experimental plot was ploughed repeatedly for 2-3 times and land was brought to a fine tilth. About 20 tones of FYM per hectare and the recommended basal dose of fertilizers (25:50:50 kg NPK) were incorporated into the soil just before sowing. The remaining 25 kg of nitrogen was applied as a top dress at 45 days after sowing. Ridges and furrows were opened at a distance of 1.5 meter apart. Two seeds of each genotype per hill were dibbled at a distance of 1 meter in a row. Irrigation, weed control and other cultural practices were followed as per the package of practices of UHS, Bagalkot (Anon., 2014). General view of experimental plot is presented in Plate 1.

**Table 3. Details of cucumber genotypes used in the present study**

Sl. No.	GENOTYPES
1	KRCCH -CC- 1
2	KRCCH -CC- 2
3	KRCCH -CC- 3
4	KRCCH -CC- 4
5	KRCCH -CC- 5
6	KRCCH -CC- 6
7	KRCCH -CC- 7
8	KRCCH -CC- 8
9	KRCCH -CC- 9
10	KRCCH -CC- 10
11	KRCCH -CC- 11
12	KRCCH -CC- 12
13	KRCCH -CC- 13
14	KRCCH -CC- 14
15	KRCCH -CC- 15
16	KRCCH -CC- 16
17	KRCCH -CC- 17
18	KRCCH -CC- 18
19	KRCCH -CC- 19
20	KRCCH CC- 20
21	Arabhavi local

KRCCH-CC: Kittur Rani Channamma College of Horticulture, Cucumber Collections.

### **3.4 Observations recorded**

Five randomly chosen plants in each replication of each entry were labeled and used for recording the observations. The mean of five plants were taken for analysis. The characters studied and techniques adopted to record the observations are given below.

#### **3.4.1 Growth parameters**

##### **3.4.1.1 Vine length (cm)**

The vine length of cucumber was measured by using meter scale from base of the plant to the growing tip of vine at 60 days after sowing.

##### **3.4.1.2 Number of leaves per vine**

Number of leaves in each tagged plant were counted at 60 days after sowing.

##### **3.4.1.3 Number of branches per vine**

The number of primary branches that have emerged from the vine was counted at 60 days after sowing.

#### **3.4.2 Flowering and earliness parameters**

##### **3.4.2.1 Days to first male flowering**

Number of days taken from date of sowing to the date of first male flower appearance in each genotypes was recorded.

##### **3.4.2.2 Node at first male flowering**

Number of nodes from ground level to the node at which first male flower appeared was counted.

##### **3.4.2.3 Number of male flowers per vine**

Total number of male flowers in five randomly tagged vines in each genotype were counted.



**Plate 1: Early growth phase of cucumber crop**



**General view of cucumber experimental block**

#### **3.4.2.4 Days to first female flowering**

Number of days taken from date of sowing to the date of first female flower appearance in each treatment was counted.

#### **3.4.2.5 Node at first female flowering**

Number of nodes from base of the plant to the node at which first female flower appeared was recorded.

#### **3.4.2.6 Number of female flowers per vine**

Total numbers of female flowers in five randomly tagged vines were counted.

#### **3.4.2.7 Days to 50 per cent flowering**

Number of days taken from the date of sowing to the date on which 50 per cent of vines in a plot flowered were recorded.

#### **3.4.2.8 Days to first harvest**

Number of days taken from the date of sowing to days at which first harvesting was done.

#### **3.4.2.9 Sex ratio**

Total number of female and male flowers were counted during the peak flowering period and sex ratio was calculated using following formula,

$$\text{Sex ratio} = \frac{\text{Number of male flowers}}{\text{Number of female flowers}}$$

### **3.4.3 Yield parameters**

#### **3.4.3.1 Fruit length (cm)**

The five randomly selected fruits were selected for measuring the fruit length. The length of the fruit was measured from the fruit stalk to the tip of the fruit and mean of five fruits was worked out and expressed in cm.

#### **3.4.3.2 Fruit diameter (cm)**

The five fruits harvested from randomly selected tagged plants were used for measuring the fruit diameter and the average was worked out and expressed in cm.

#### **3.4.3.3 Average fruit weight (g)**

The five randomly selected fruits (harvested from the five labeled vines) were weighed using weighing scale and their mean fresh weight was recorded from first to last harvest and expressed in grams.

#### **3.4.3.4 Number of fruits per vine**

Total number of fruits obtained in each plant was recorded from five labeled plants and mean value per plant was worked out.

#### **3.4.3.5 Fruit yield per vine (kg)**

The total yield obtained from each vine was recorded from the five labeled plants from first harvest to last harvest and the mean was calculated.

### **3.4.4 Quality parameters**

#### **3.4.4.1 Flesh thickness (cm)**

The flesh thickness of cucumber fruits was measured at the broadest point of the fruit and the mean values arrived for five individual fruits per genotype in each replication was recorded.

#### **3.4.4.2 Hairiness of fruit**

At edible maturity stage hairiness of the fruit was recorded. Average of five fruits was worked out and results were expressed as smooth, rough and hairy.

#### **3.4.4.3 Bitterness**

Bitterness of the fruit was recorded by randomly selecting five fruits and evaluated by sensory evaluation.

### **3.4.5. Seed parameters**

#### **3.4.5.1 Number of seeds per fruit**

The seeds extracted from each fruit in each treatment and replication were counted and the average was computed and recorded.

#### **3.4.5.2 Seed yield per fruit (g)**

Seeds from all the fruits were harvested from five tagged vines for seed extraction purpose and the seeds were extracted and weighed. The average value was worked out for five vines.

#### **3.4.5.3 Seed length (cm)**

Ten seeds were selected from the seeds extracted from the fruits and seed length was measured and expressed in cm.

#### **3.4.5.4 Seed width (cm)**

Ten seeds were selected from the seeds extracted from the fruits as per the treatment and seed width was measured using vernier calipers.

#### **3.4.5.5 Seed test weight (g)**

Hundred seeds extracted from each fruits of all genotype were weighed using weighing scale and expressed in grams.

### **3.4.6 Pest and disease incidence**

#### **3.4.6.1 Powdery mildew incidence**

The per cent powdery mildew incidence was recorded at 55, 70 and 85 days after sowing as per cent leaf area infested for all the genotypes, which were scored by following zero to four disease rating scale as given below (Girisha, 1989).

Sl. No.	Per cent leaf area infected	Score	Reaction category
1	0	0	Immune
2	1-10	1	Resistant
3	11-25	2	Moderately resistant
4	26-50	3	Moderately susceptible
5	51-75	4	Susceptible

#### 3.4.6.2 Fruit fly infestation (%)

The number of fruits infested by fruit fly was counted at each harvest, total fruits and infested fruits per genotype was worked out. Per cent incidence of fruit fly was computed by using following formula (Nath, 1966).

$$\text{Fruit fly incidence (\%)} = \frac{\text{Number of fruits infested}}{\text{Total number of fruits}} \times 100$$

Further genotypes were grouped into different categories based on per cent of fruit infestation as given below.

Per cent fruit infestation	Reaction categories
0 – 10	Resistant
11 – 25	Moderately resistant
26 – 50	Moderately susceptible
51 – 75	Susceptible
> 75	Highly susceptible

### 3.5 Statistical analysis

The data on various observations such as growth, yield and quality parameters were tabulated and subjected to statistical analysis and following different statistical parameters were worked out.

### 3.5.1 Analysis of variance (ANOVA)

Analysis of variance was carried out as per the procedure given by Panse and Sukthame (1967) using the mean values of random plants in each replication from all the genotypes to find out the significance of genotype effects.

The model of analysis of variance is given below.

Source	D. F	SS	MSS	Cal. F
Replication	r-1	RSS	RSS/ (r-1)	-
Treatments	t-1	TSS	TSS/ (t-1)	TMSS/ EMSS
Error	(r-1) (t-1)	ESS	ESS/ (r-1) (t-1)	-
Total	(rt-1)	-	-	-

Where, t = Number of treatments (Genotypes)

r = Number of replications

Standard error was calculated as,

$$SEm = \frac{\sqrt{EMSS}}{r}$$

The significance of treatments, mean square and replication mean square were calculated by comparing with error mean squares referring to 'F' table values at 5 and 1 per cent level of probabilities.

### 3.5.2 Estimation of genetic parameters

#### 3.5.2.1 Genotypic, phenotypic and environmental variances

Variance due to genotype, phenotype and environment were computed as follows.

$$\text{Genotypic variance } (\sigma_g^2) = \frac{\text{MS due to genotypes (adj)} - \text{MS due to error (intra block)}}{r \text{ (replication)}}$$

Environmental variance ( $\sigma_e^2$ ) = Error mean sum of squares

Phenotypic variance ( $\sigma_p^2$ ) =  $\sigma_g^2 + \sigma_e^2$  (MS due to error)

Where, 'r' is a number of replication.

### 3.5.2.2 Genotypic and phenotypic coefficient of variation

Genotypic and phenotypic coefficients of variance were estimated according to Burton and Devane (1953) based on estimate of genotypic and phenotypic variance.

#### Genotypic coefficient of variance (GCV)

$$\text{GCV (\%)} = \frac{\sigma_g}{\bar{X}} \times 100$$

#### Phenotypic coefficient of variance (PCV)

$$\text{PCV (\%)} = \frac{\sigma_p}{\bar{X}} \times 100$$

Where,

$\bar{X}$  = Grand mean

$\sigma_g$  = Genotypic standard deviation

$\sigma_p$  = Phenotypic standard deviation

### 3.5.2.3 Heritability ( $h^2$ )

Heritability in broad sense was calculated as the ratio of genotypic variance to the phenotypic variance and expressed in percentage (Falconer, 1981).

$$\text{Heritability (}h^2\text{)} = \frac{\sigma^2 g}{\sigma^2 p} \times 100$$

Where,  $h^2$  (%) = broad sense heritability

$\sigma^2 g$  = Genotypic variance

$\sigma^2 p$  = Phenotypic variance

### 3.5.2.4 Genetic advance

Genetic advance (GA) for each character was calculated using the formula given by Johnson *et al.* (1955).

$$\text{Genetic advance (GA)} = k \times h^2 \times \sigma_p$$

Where, k = Selection differential (2.06) at 5 per cent selection intensity

$h^2$  = Heritability in broad sense

$\sigma_p$  = Phenotypic standard deviation

### 3.5.2.5 Genetic advance as per cent over mean (GAM)

Genetic advance as per cent over mean was worked out as suggested by Johnson *et al.*, (1955) and is given below.

$$\text{Genetics advance over mean (GAM)} = \frac{\text{GA}}{\bar{X}} \times 100$$

Where, GA = Genetic advance

$\bar{X}$  = General mean of the character

0-10 % : Low

11-20% : Moderate

21% and above : High

### 3.5.3 Genotypic and phenotypic correlation coefficients

Genotypic ( $r_g$ ) and phenotypic ( $r_p$ ) correlation coefficients were estimated as suggested by Al-Jibourie *et al.* (1958).

$$\text{Genotypic correlation} = r_{xy}(g) = \frac{\text{Cov}_{xy}(g)}{\sqrt{V_x(g) \times V_y(g)}}$$

$$\text{Phenotypic correlation} = r_{xy}(p) = \frac{\text{Cov}_{xy}(p)}{\sqrt{V_x(p) \times V_y(p)}}$$

Where,  $\text{Cov}_{xy}(G)$  = Genotypic covariance between x and y

$\text{Cov}_{xy}(P)$  = Phenotypic covariance between x and y

$V_x(G)$  = Genotypic variance of character 'x'

$V_x(P)$  = Phenotypic variance of character 'x'

$V_y(G)$  = Genotypic variance of character 'y'

$V_y(P)$  = Phenotypic variance of character 'y'

Test of significance for association between characters was carried out by comparing table 'r' values at n-2 errors of degrees of freedom for phenotypic and genotypic correlation with estimated values respectively.

### 3.5.4 Path coefficient analysis

Path coefficient analysis was suggested by Wright (1921) and illustrated and carried out separately by Dewey and Lu (1959) to know the direct and indirect effects of the important component traits on total yield per plant. Standard path coefficients, which are the standardized partial regression coefficients were obtained by solving the following set of 'P' simultaneous equations through 'Doolittle technique' as given by Goulden (1959).

The path coefficients were obtained by simultaneous selection of the following equations, which expresses the basic relationship between genotypic correlation 'r' and path coefficients 'p'.

$$r_{14}: P_{14} + P_{24} r_{12} + P_{34} r_{13}$$

$$r_{24}: P_{14} r_{21} + P_{24} + P_{34} r_{23}$$

$$r_{34}: P_{14} r_{31} + P_{24} r_{32} + P_{34}$$

Where,  $r_{14}$ ,  $r_{24}$  and  $r_{34}$  are genotypic correlation of component characters with yield (dependent variable) and  $r_{12}$ ,  $r_{13}$  and  $r_{23}$  are the genotypic correlations among component characters (independent variable).

The direct effects were calculated by the following set of equations:

$$P_{14}: C_{11} r_{14} + C_{12} r_{24} + C_{13} r_{34}$$

$$P_{24}: C_{21} r_{14} + C_{22} r_{24} + P_{23} r_{34}$$

$$P_{34}: C_{31} r_{14} + C_{32} r_{24} + C_{33} r_{34}$$

$C_{11}$ ,  $C_{22}$ ,  $C_{23}$  and  $C_{33}$  are constants derived by using abbreviated Doolittle's technique as explained by Goulden (1959).

$r_{12} P_{24}$ ,  $r_{13} P_{34}$ ,  $r_{21} P_{14}$ ,  $r_{23} P_{34}$ ,  $r_{31} P_{14}$ ,  $r_{32} P_{24}$  are indirect effects.

### 3.6.5. Residual effects

The variation in the dependent variable which remained undetermined by including all the variables was assumed to be due to variables (s) not included in the present investigation. The degree of determination of such variables (s) on dependent variable was calculated as follows:

$$1 = P_{2x4} + P_{142} + P_{342} + 2P_{14} r_{12} P_{24} + 2P_{14} r_{13} P_{34} + 2P_{24} r_{23} P_{34}$$

Scale for path coefficients,

Values of direct (or) indirect effects	Rate (or) scale
0.00 to 0.09	Negligible
0.10 to 0.19	Low
0.20 to 0.29	Moderate
0.30 to 0.99	High
> 1.00	Very high

### 3.5.5 Genetic divergence analysis

Genetic divergence between genotypes was estimated using Mahalanobis's  $D^2$  statistic (1936). The distance  $D$  from the sample was computed using the formula,

$$D^2_p = d^1 S^{-1} d$$

Where,

$D^2_p$  = Square of distance considering 'p' variables

$d$  = Vector observed differences of the mean values of all the characters  
( $x_{i1} - x_{i2}$ )

$S^{-1}$  = Inverse of variance and covariance matrix.

#### 3.5.5.1 Clustering of genotypes

Using all  $D^2$  values, the genotypes were grouped into clusters using Tocher's method as described by Rao (1952).

#### 3.5.5.2 Intra- and Inter-cluster distances

The intra and inter-cluster distances were calculated by the formula given by Singh and Choudhary (1985).

$$\text{Intra-cluster distance} = \frac{\sum D_i^2}{n}$$

Where,

$\sum D_i^2$  is the sum of  $D^2$  values between all possible combinations of the genotypes included in clusters 'i'.

$n$  = number of all possible combinations

$$\text{Intra-cluster distance} = \frac{\sum D_i^2}{n_i n_j}$$

Where,

$\Sigma Di^2$  is the sum of distances between all possible combinations ( $n_i n_j$ ) of the genotypes included in the clusters 'i' and 'j'.

$n_i$  = Number of genotypes in cluster 'i'

$n_j$  = Number of genotypes in cluster 'j'.

### 3.5.5.3 Contribution of individual characters towards genetic divergence

The character contribution towards genetic divergence was computed by using the method given by Singh and Choudhary (1985). In all the combination, each character is ranked on the basis of

$$d_i = y_i^j - y_i^k \text{ values.}$$

Where,

$D_i$  = Mean deviation

$y_i^j$  = Mean value of the  $j^{\text{th}}$  genotype for  $i^{\text{th}}$  character and

$y_i^k$  = Mean value of the  $k^{\text{th}}$  genotype for  $i^{\text{th}}$  character

Rank '1' is given to the highest mean difference and rank p is given to the lowest mean difference.

Where,

P is total number of characters.

Finally, another table giving information on number of times that each character appeared in the first rank is prepared and per cent contribution of characters towards divergence was calculated.

## **4. EXPERIMENTAL RESULTS**

A field experiment on “Assessment of genetic variability in local collections of cucumber (*Cucumis sativus* L.) genotypes for productivity traits” comprises of 20 cucumber genotypes along with check was laid out in a randomized complete block design with all recommended packages of practices during 2017-18. Extent of genetic variability for morphological and quality parameters, path analysis and correlation between yield and yield components, genetic diversity of genotypes based on yield and yield components was studied. The results obtained from the present investigation are present under the following headings.

- 4.1 Genetic variability
- 4.2 Character association
- 4.3 Path analysis
- 4.4 Genetic diversity

### **4.1 Genetic variability**

#### **4.1.1 Analysis of Variance**

Analysis of variance was calculated to test the significant difference among the genotypes. Values of replication mean sum of square, treatment mean sum of square, error mean sum of square and critical difference at both one per cent and five per cent level of significance are presented in the Table 4. The result from analysis of variance revealed significant difference for growth, earliness, fruit yield, quality and seed parameters studied among genotypes for all the characters.

#### **4.1.2 Genetic variability, heritability and genetic advance**

The results of estimates of mean, range, phenotypic variance (PV), genotypic variance (GV), phenotypic coefficient variance (PCV), genotypic coefficient variance (GCV), heritability ( $h^2$ ), genetic advance (GA) and genetic advance as per cent over mean (GAM) for 24 traits are presented in the Table 5. The mean performance of the

**Table 4: Mean sum of square for growth, earliness, yield, quality and seed parameters in cucumber genotypes**

Sl.No	Source of variation/ character	Replication	Genotypes	Error	CD (5%)	CD (1%)
	Degrees of freedom	1	20	20		
<b>A</b>	<b>Growth parameters</b>					
1	Vine length (cm)	359.04	1818.79**	152.84	25.78	35.17
2	Number of leaves per vine	640.38	1321.35**	31.98	11.79	16.09
3	Number of branches per vine	1.40	2.09**	0.16	0.85	1.16
4	Number of nodes per vine	32.77	10.36**	2.87	3.50	4.78
<b>B</b>	<b>Earliness and yield parameters</b>					
1	Node at first male flower	4.21	1.43**	0.26	1.06	1.45
2	Node at first female flower	0.09	2.39**	0.32	1.18	1.61
3	Days to first male flowering	18.00	30.66**	10.34	6.70	9.15
4	Days to first female flowering	504.74	34.29**	12.24	7.30	9.95
5	Days to 50 per cent flowering	392.23	50.63*	21.10	9.58	13.07
6	Number of male flowers	582.40	497.60**	35.16	12.37	16.87
7	Number of female flowers	74.80	11.93**	0.64	1.67	2.27
8	Sex ratio	51.92	19.14*	2.63	3.38	4.62
9	Days to first fruit harvesting	73.60	35.46*	14.55	7.95	10.85
10	Number of fruits per vine	13.48	7.91**	0.20	0.94	1.29
11	Average fruit weight (g)	4414.67	7374.32**	629.50	52.33	71.39
12	Fruit yield per vine (kg)	0.74	0.46**	0.01	0.23	0.31
13	Fruit length (cm)	114.34	66.18**	3.86	4.09	5.59
14	Fruit diameter (cm)	15.78	3.67**	0.43	1.37	1.86

\*\* Significant at 1% probability, \* Significant at 5% probability

Contd...

Sl. No	Source of variation/ character	Replication	Genotypes	Error	CD (5%)	CD (1%)
	Degrees of freedom	1	20	20		
<b>C</b>	<b>Quality parameter</b>					
1	Flesh thickness (cm)	0.85	0.24*	0.09	0.62	0.85
<b>D</b>	<b>Seed parameter</b>					
1	Number of seeds per fruit	1219.86	4767.24*	204.07	29.79	40.64
2	Seed yield per fruit (g)	1.39	4.10*	0.08	0.61	0.84
3	Seed length (cm)	0.02	0.04*	0.01	0.24	0.32
4	Seed width (cm)	0.01	0.008*	0.003	0.12	0.16
5	Test weight (g)	1.69	0.50*	0.05	0.48	0.65

\*\* Significant at 1% probability

\* Significant at 5% probability

genotypes for various characters is presented in Appendix- II. Phenotypic and genotypic coefficients of variability are presented in Fig 1, whereas, heritability and genetic advance as per cent mean presented in Fig 2.

#### **4.1.2.1 Vine length (cm)**

Wide range of variability was observed among cucumber genotypes for vine length. It ranging from 103.75 cm (KRCCH-CC-3) to 218.00 cm (KRCCH-CC-8) with a grand mean of 152.39 cm. The estimates of genotypic coefficient of variation and phenotypic coefficient of variations were 18.93 and 20.60 per cent respectively. High heritability of 84 per cent was coupled with genetic advance as per cent over mean (GAM) 35.86 per cent was observed.

#### **4.1.2.2 Number of leaves per vine**

Number of leaves per vine ranged from 28.50 to 117.00 with the grand mean of 66.14. Maximum number of leaves per vine were recorded in KRCCH-CC-1 followed by KRCCH-CC-18, KRCCH-CC-8 and KRCCH-CC-11. Whereas, KRCCH-CC-2 recorded minimum number of leaves followed by KRCCH-CC-3 and KRCCH-CC-12. The estimates of genotypic coefficient of variation and phenotypic coefficient of variations were 38.38 and 39.32 per cent respectively. High heritability of 95 per cent was observed. The genetic advance as per cent over means (GAM) was found to be 77.18 per cent.

#### **4.1.2.3 Number of branches per vine**

The number of branches per vine ranged from 1.35 to 4.72 with the grand mean of 2.72. The maximum number of branches were observed in KRCCH-CC-17 followed by KRCCH-CC-15 and KRCCH-CC-3. Whereas, minimum number of branches were recorded in KRCCH-CC-4 followed by KRCCH-CC-14, KRCCH-CC-6, KRCCH-CC-16 and KRCCH-CC-2. The estimates of genotypic coefficient of variation and phenotypic coefficient of variations were 36.07 and 39.08 per cent respectively. High heritability of 85 per cent was recorded along with high genetic advance as per cent over mean GAM (68.59%).

#### **4.1.2.4 Number of nodes per vine**

Number of nodes per vine varied from 8.25 to 15.87 with a mean value of 12.14. The maximum number of nodes per vine was recorded in KRCCH-CC-5 followed by KRCCH-CC-16, KRCCH-CC-9 and KRCCH-CC-8. Whereas, minimum number of nodes per vine was recorded in KRCCH-CC-14 followed by KRCCH-CC-7 and KRCCH-CC-12. The estimates of genotypic coefficient of variation (15.98%) and phenotypic coefficient of variations (21.15%) were associated with moderate heritability of 57 per cent and genetic advance as per cent over mean was found to be 24.89 per cent.

#### **4.1.2.5 Node at first male flower**

Node at first male flower ranged from 1.4 to 3.95 with the grand mean of 2.66. KRCCH-CC-5 showed early node at first male flowering followed by KRCCH-CC-9, KRCCH-CC-14 and KRCCH-CC-7. Whereas, it was contrast with KRCCH-CC-17, KRCCH-CC-15 and KRCCH-CC-19. The estimates of genotypic coefficient of variation and phenotypic coefficient of variations were 28.76 and 34.58 per cent respectively. High heritability of 69 per cent was observed. The genetic advance as per cent over means (GAM) was found to be 49.29 per cent for this trait.

#### **4.1.2.6 Node at first female flower**

Node at first female flower ranged from 2.85 (KRCCH-CC-6) to 7.80 (KRCCH-CC-1) with the grand mean of 5.02. The estimates of genotypic coefficient of variation and phenotypic coefficient of variations were 20.26 and 23.19 per cent respectively. High heritability of 76 per cent was noticed for this trait along with high genetic advance (GAM) of 36.48 per cent.

#### **4.1.2.7 Days to first male flower appearance**

KRCCH-CC-18 took 26 days for first male flower appearance followed by check (Arabhavi local). Whereas, KRCCH-CC-1 took 43.25 days followed by KRCCH-CC-17. The overall grand mean obtained was 36.48 days. Genotypic coefficient of variation was recorded to be 8.73 per cent and phenotypic coefficient of variation was

12.41 per cent. Moderate heritability of 49 per cent was coupled with moderate genetic advance (12.69%).

#### **4.1.2.8 Days to first female flowering**

Large variation for days to first female flowering was observed among the cucumber genotypes ranging from 31 days to 49.25 days with a grand mean of 42.65 days. Early female flowering was recorded in KRCCH-CC-18 followed by check (Arabhavi local). Whereas, late female flowering was observed in KRCCH-CC-1. Low genotypic coefficient of variation of 7.78 per cent with moderate phenotypic coefficient of variation 11.31 was recorded. Moderate heritability of 47 per cent was coupled with moderate genetic advance of 11.03 per cent was recorded for this trait.

#### **4.1.2.9 Days to 50 per cent flowering**

Days to 50 per cent flowering ranged from 40.5 (KRCCH-CC-19 and Arabhavi local) to 61.85 (KRCCH-CC-1) with the grand mean of 53.24. The estimates of genotypic coefficient of variation and phenotypic coefficient of variations were 7.21 and 11.24 per cent respectively. Moderate heritability of 41 per cent was recorded along with low genetic advance as per cent over mean (9.53%).

#### **4.1.2.10 Number of male flowers per vine**

Number of male flowers per vine varied from 47.80 to 102.35 with the grand mean of 70.64. The maximum number of male flowers per vine were recorded in KRCCH-CC-8 followed by KRCCH-CC-4 and KRCCH-CC-1. Whereas, minimum number of male flowers per vine was recorded in KRCCH-CC-3. The estimates of genotypic coefficient of variation (21.52%) and phenotypic coefficient of variations (23.10%) were associated with high heritability of 86 per cent and genetic advance as per cent over mean was found to be 41.31 per cent.

#### **4.1.2.11 Number of female flowers per vine**

Number of female flowers per vine ranged from 4.40 to 14.55 with the grand mean of 8.41. The maximum number of female flowers per vine were recorded in KRCCH-CC-16 followed by KRCCH-CC-17. Whereas, minimum number of female

flower per vine were recorded in KRCCH-CC-12 followed by KRCCH-CC-11, KRCCH-CC-7 and KRCCH-CC-19. The estimates of genotypic coefficient of variation (28.22%) and phenotypic coefficient of variations (29.76%) were associated with high heritability of 89 per cent and genetic advance as per cent over mean was found to be 55.09 per cent.

#### **4.1.2.12 Sex ratio**

Sex ratio varied from 4.2 (KRCCH-CC-7) to 15.35 (KRCCH-CC-12) with a mean value of 9.23. Genotypic coefficient of variation was recorded to be 31.10 per cent and phenotypic coefficient of variation was 35.72 per cent. High heritability of 75 per cent was coupled with high genetic advance as per cent over mean (55.76%).

#### **4.1.2.13 Days to first fruit harvesting**

Days to first fruit harvesting ranged from 48 days to 61.75 days with a grand mean 53.40 days. The genotype, KRCCH-CC-6 recorded early (48 days) compared to check (Arabhazi local). Whereas, KRCCH-CC-1 took maximum number of days (61.75 days) for first fruit harvesting. The estimates of low genotypic coefficient of variation (6.05%) and phenotypic coefficient of variation (9.36%) was associated with moderate heritability of 41 per cent and genetic advance as per cent over mean was found to be 8.06 per cent.

#### **4.1.2.14 Flesh thickness (cm)**

Flesh thickness of the fruits varied from 1.27 cm (KRCCH-CC-1) to 2.8 cm (Arabhazi local) with a grand total mean of 2.02. Genotypic coefficient of variation was 13.48 per cent, whereas, phenotypic coefficient of variation was 20.06 per cent. Moderate heritability of 45 per cent coupled with high genetic advance of 18.66 per cent.

#### **4.1.2.15 Fruit diameter (cm)**

Fruit diameter ranged from 4.00 cm to 8.62 cm with the average mean of 5.93 cm. The maximum fruit diameter was observed in KRCCH-CC-1 followed by KRCCH-CC-8, KRCCH-CC-17 and KRCCH-CC-14. Whereas, minimum fruit diameter was observed in KRCCH-CC-3 followed by KRCCH-CC-21, KRCCH-CC-10, KRCCH-

CC-15 and KRCCH-CC-16. The coefficient of variability at phenotypic and genotypic level was 21.44 per cent and 24.12 per cent respectively. High heritability of 78 per cent with 39.25 per cent GAM was recorded.

#### **4.1.2.16 Number of fruits per vine**

Number of fruits per vine varied from 2.62 to 9.62 with a mean value of 5.37. Maximum number of fruits were recorded in KRCCH-CC-17 followed by KRCCH-CC-16 and KRCCH-CC-15. Whereas, minimum number of fruits were observed in KRCCH-CC-12 followed by KRCCH-CC-9 and KRCCH-CC-7. Genotypic coefficient of variation was recorded to be 36.53 per cent and phenotypic coefficient of variation was 37.49 per cent. High heritability of 94 per cent coupled with high genetic advance as per cent over mean (73.31%) was noticed.

#### **4.1.2.17 Average fruit weight (g)**

Average fruit weight varied significantly from 93.55 g to 349.00 g with a mean value 199.32 g. Highest average fruit weight of 349 g was recorded in KRCCH-CC-6. Whereas, lowest average fruit weight was recorded in KRCCH-CC-5. The genotypic and phenotypic coefficient of variations for this character was 29.13 and 31.73 per cent respectively. High heritability of 84 per cent coupled with high genetic advance as per cent over mean (55.09%) was recorded for this trait.

#### **4.1.2.18 Fruit yield per vine (kg)**

Fruit yield per vine varied from 0.61 kg to 2.5 kg with a mean value 1.25 kg. Maximum fruit yield was obtained in KRCCH-CC-15 followed by KRCCH-CC-13. Whereas, check (Arabhavi local) had minimum yield compared with other genotypes. Genotypic coefficient of variation was recorded to be 37.90 per cent and phenotypic coefficient of variation was 38.92 per cent. High heritability of 94 per cent was coupled with high genetic advance as per cent over mean (76.03%) was observed.

#### **4.1.2.19 Fruit length (cm)**

A wide variation was observed among cucumber genotypes for fruit length. It varied significantly among the genotypes with a mean value of 17.59 cm and ranged of

6.00 to 26.20 cm. KRCCH-CC-17 recorded maximum fruit length followed by KRCCH-CC-7 and KRCCH-CC-15. Whereas, KRCCH-CC-19 recorded minimum fruit length followed by KRCCH-CC-18 and KRCCH-CC-20. The genotypic and phenotypic coefficient of variations for this character was 31.72 and 33.63 per cent respectively. This trait recorded high heritability of 88 per cent coupled with high genetic advance as per cent over mean (61.65%).

#### **4.1.2.20 Number of seeds per fruit**

Number of seeds per fruit varied from 57.62 to 257.75 with a mean value 149.23. Maximum numbers of seeds were observed in KRCCH-CC-6 which was on par with KRCCH-CC-7. Whereas, minimum number of seeds were obtained in KRCCH-CC-1 followed by KRCCH-CC-5, KRCCH-CC-16 and KRCCH-CC-21. Genotypic coefficient of variation was recorded to be 32.00 per cent and phenotypic coefficient of variation was 33.40 per cent. High heritability of 91 per cent was coupled with high genetic advance as per cent over mean (63.16%).

#### **4.1.2.21 Seed yield per fruit (g)**

Seed yield per fruit ranged from 0.42 g (KRCCH-CC-6) to 6.75 g (Arabhavi local) with the grand mean of 3.08. The estimates of genotypic coefficient of variation (45.89%) and phenotypic coefficient of variations (46.88%) were associated with high heritability of 95 per cent. Genetic advance as per cent over mean was found 92.55 per cent.

#### **4.1.2.22 Seed length (cm)**

Seed length ranged from 0.64 cm (KRCCH-CC-2) to 1.16 cm (KRCCH-CC-4) with the grand mean of 0.85 cm. The estimates of genotypic coefficient of variation and phenotypic coefficient of variation were 14.45 and 19.75 per cent respectively. High heritability of 53 per cent was recorded along with moderate genetic advance as per cent over mean (21.79%).

#### **4.1.2.23 Seed width (cm)**

Seed width varied from 0.32 cm (KRCCH-CC-11) to 0.52 cm (KRCCH-CC-17) with a grand total mean of 0.42 cm. The coefficients of variability at phenotypic and

**Table 5 : Genetic parameters for different traits in cucumber**

Sl. No.	Character	Range		Mean $\pm$ SEm	PV	GV	PCV (%)	GCV (%)	h <sup>2</sup> (%) (bs)	GA	GAM (%)
		Min	Max								
<b>A</b>	<b>Growth parameters</b>										
1	Vine length (Cm)	103.75	218.00	152.39 $\pm$ 8.53	985.81	832.97	20.60	18.93	84	54.65	35.86
2	Number of leaves per vine	28.50	117.00	66.14 $\pm$ 3.90	678.66	644.68	39.32	38.38	95	51.05	77.18
3	Number of branches per vine	1.35	4.72	2.72 $\pm$ 0.28	1.13	0.96	39.08	36.07	85	1.86	68.59
4	Number of nodes per vine	8.25	15.87	12.14 $\pm$ 1.16	6.59	3.76	21.15	15.98	57	3.02	24.89
<b>B</b>	<b>Earliness of parameters</b>										
1	Node at first male flower	1.4	3.95	2.66 $\pm$ 0.35	0.84	0.58	34.58	28.76	69	1.31	49.29
2	Node at first female flower	2.85	7.80	5.02 $\pm$ 0.39	1.35	1.03	23.19	20.26	76	1.83	36.48
3	Days to first male flowering	26.00	43.25	36.48 $\pm$ 2.21	20.50	10.16	12.41	8.73	49	4.62	12.69
4	Days to first female flowering	31.00	49.25	42.65 $\pm$ 2.41	23.27	11.02	11.31	7.78	47	4.70	11.03
5	Days to 50 per cent flowering	40.50	61.85	53.24 $\pm$ 3.17	35.86	14.76	11.24	7.21	41	5.07	9.53
6	Number of male flowers	47.80	102.35	70.64 $\pm$ 4.09	266.38	231.22	23.10	21.52	86	29.18	41.31
7	Number of female flowers	4.40	14.55	8.41 $\pm$ 0.55	6.28	5.64	29.76	28.22	89	4.63	55.09
8	Sex ratio	4.20	15.35	9.23 $\pm$ 1.12	10.88	8.25	35.72	31.10	75	5.15	55.76
9	Days to first fruit harvesting	48.00	61.75	53.40 $\pm$ 2.63	25.00	10.45	9.36	6.05	41	4.30	8.06
10	Fruit diameter (cm)	4.00	8.62	5.93 $\pm$ 0.45	2.05	1.62	24.12	21.44	78	2.33	39.25
<b>C</b>	<b>Quality parameters</b>										
1	Flesh thickness (cm)	1.27	2.80	2.02 $\pm$ 0.20	0.16	0.07	20.06	13.48	45	0.37	18.66

Sl. No.	Character	Range		Mean $\pm$ SEm	PV	GV	PCV (%)	GCV (%)	h <sup>2</sup> (%) (bs)	GA	GAM (%)
		Min	Max								
<b>D</b>	<b>Yield parameters</b>										
1	Number of fruits per vine	2.62	9.62	5.37 $\pm$ 0.31	4.06	3.85	37.49	36.53	94	3.93	73.31
2	Average fruit weight (g)	93.55	349.00	199.32 $\pm$ 17.31	4001.91	3372.40	31.73	29.13	84	109.80	55.09
3	Fruit yield per vine(kg)	0.61	2.50	1.25 $\pm$ 0.07	0.24	0.22	38.92	37.90	94	0.95	76.03
4	Fruit length (cm)	6.00	26.2	17.59 $\pm$ 1.35	35.02	31.16	33.63	31.72	88	10.84	61.65
<b>E</b>	<b>Seed parameters</b>										
1	Number of seeds per fruit	57.62	257.75	149.23 $\pm$ 9.85	2485.65	2281.58	33.40	32.00	91	94.27	63.16
2	Seed yield per fruit (g)	0.42	6.75	3.08 $\pm$ 0.20	2.09	2.00	46.88	45.89	95	2.85	92.55
3	Seed length (cm)	0.64	1.16	0.85 $\pm$ 0.07	0.02	0.01	19.75	14.45	53	0.18	21.79
4	Seed width (cm)	0.32	0.52	0.42 $\pm$ 0.04	0.005	0.002	17.84	11.17	39	0.06	14.14
5	Test weight (g)	0.55	2.85	2.03 $\pm$ 0.15	0.27	0.22	25.92	23.32	80	0.88	43.21

GV= Genotypic variation  
PV= Phenotypic variation

GCV= Genotypic coefficient variation  
PCV= Phenotypic coefficient variation

h<sup>2</sup> = Heritability  
GA= Genetic advance  
GAM=Genetic advance as per cent mean.

genotypic levels were 17.84 and 11.17 respectively. The values of heritability and genetic gain were 39 per cent and 14.14 per cent respectively.

#### **4.1.2.24 Test weight (g)**

Test weight ranged from 0.55 g (KRCCH-CC-6) to 2.85 g (Arabhavi local) with a mean of 2.03 g. The estimates of genotypic coefficient of variation and phenotypic coefficient of variation were 23.32 and 25.92 per cent respectively. High heritability of 80 per cent and genetic gain of 43.21 per cent could be expected.

### **4.1.3 Quality parameters**

#### **4.1.3.1 Bitterness**

Among twenty one genotypes evaluated, three genotypes were bitter in taste *viz.*, KRCCHCC8, KRCCHCC13 and KRCCHCC16. Genotype KRCCHCC6 was tasteless. Whereas, KRCCHCC9 and KRCCHCC14 were little bit sour. The remaining fourteen genotypes and check (Arabhavi local) were mild sweet in taste.

#### **4.1.3.1 Hairiness**

Three hairy type genotypes were observed *viz.*, KRCCHCC6, KRCCHCC7 and KRCCHCC13. Whereas, remaining seventeen genotypes along with check (Arabhavi local) showed absence of hairiness.

## **4.2 Character association**

The phenotypic and genotypic correlation coefficients were determined to know the nature of relationship existing between yield and its component characters as well as the association among component characters themselves. The results are presented in the Table 6 and Table 7.

### **4.2.1 Association of fruit yield per vine with its component characters**

Fruit yield per vine had positive and highly significant (1% level of significance) association with number of female flowers (0.4036), number of fruits per vine (0.4880)

and average fruit weight (0.5067). Whereas, it had negative and significant association with sex ratio (-0.4347) at phenotypic level. At genotypic level, number of branches per vine (0.3707), number of female flowers per vine (0.4323), number of fruits per vine (0.5218) and average fruit weight (0.5581) were positively and significantly (1 % level of significance) associated with fruit yield per vine. Whereas, node at first male flowering (-0.4129), days to 50 per cent flowering (-0.5524) and sex ratio (-0.4902) were negatively and significantly (1 % level of significance) associated.

#### **4.2.2 Phenotypic correlation coefficient between different yield components in cucumber genotypes (Table 6)**

##### **4.2.2.1 Vine length (cm)**

Vine length is positively and significantly correlated with number of male flowers per vine (0.3679) and fruit diameter (0.3476). While, it is positively and non-significantly correlated with number of leaves per vine (0.2901), number of nodes per vine (0.2184), node at first male flower appearance (0.1881), flesh thickness (0.1330) and number of female flowers (0.1318) at one and five per cent level of significance. It was negatively and significantly correlated with days to first female flowering (-0.4298) and was negatively and non-significantly correlated with days to first male appearance (-0.2463), days to 50 per cent flowering (-0.2949), average fruit weight (-0.1799), node at first female flower (-0.1772) and days to first fruit harvest (-0.1065).

##### **4.2.2.2 Number of leaves per vine**

Number of leaves per vine (at both 1% and 5% level of significance) had positive and significant correlation with number of male flowers per vine (0.6899) and fruit diameter (0.3965). Number of female flowers (0.1557), sex ratio (0.2917) and number of fruits per vine (0.1114) and flesh thickness (0.1317) were positively non-significant. Days to 50 per cent flowering (-0.3333) and days to first fruit harvest (-0.3165) were negatively and significantly associated. Whereas, node at first female flower (-0.2207) and days to first female flowering (-0.1737) are negatively and non-significantly correlated.

#### 4.2.2.3 Number of branches per vine

Number of branches per vine (both at 1% and 5% level of significance) has positive and significant correlation with number of fruits per vine (0.3525). Whereas, flesh thickness (0.2332), fruit length (0.1981) and number of female flowers (0.1760) were positively and non-significantly associated. Traits like days to first male flowering (-0.2712), days to 50 per cent flowering (-0.2586), days to first fruit harvest (-0.1838), node at first female flower (-0.1744), days to first female flowering (-0.1695), sex ratio (-0.1474) and number of nodes per vine (-0.1392) exhibited negative and non-significant correlation.

#### 4.2.2.4 Number of nodes per vine

Number of nodes per vine (both at 1% and 5% level of significance) has positive and significant correlation with number of female flowers per vine (0.3333). While, days to 50 per cent flowering (0.3092), days to first male flower appearance (0.1991), days to first female flowering (0.1628), node at first male flower (0.1472) and number of male flowers (0.1033) were positively and non-significantly correlated. There was a negative and significant correlation with average fruit weight (-0.3558). Negative and non-significant correlation was observed for sex ratio (-0.2400), fruit diameter (-0.2317), fruit length (-0.1729) and flesh thickness (-0.1325).

#### 4.2.2.5 Node at first male flowering

Node at which first male flower appears (both at 1% and 5% level of significance) has positive and significant correlation with node at first female flowering (0.3797). Positive and non-significant correlation was observed among days to first male flower appearance (0.1421), days to first female flowering (0.1574), number of male flowers per vine (0.1503), sex ratio (0.2578), days to first fruit harvest (0.2238) and flesh thickness (0.2378). Whereas, number of fruits per vine (-0.4200) and average fruit weight (-0.3083) had negative and significant correlation. While, number of female flowers (-0.2663) showed negative non-significant correlation.

#### 4.2.2.6 Node at first female flowering

Node at first female flowering (both at 1% and 5% level of significance) has positive and significant correlation with days to first female flowering (0.4385) and days to first male flower appearance (0.3133). Positive and non-significant correlation was observed with days to 50 per cent flowering (0.1406). Number of fruits per vine (-0.3775) had negative and significant association. While, number of female flowers (-0.2800), average fruit weight (-0.2467) and number of male flowers per vine (-0.1686) were negatively and non-significantly correlated.

#### 4.2.2.7 Days to first male flowering

Days to first male flowering (both at 1% and 5% level of significance) has positive and significant correlation with days to first female flowering (0.6388) and days to 50 per cent flowering (0.3225). Positive and non-significant association was found for number of male flowers per vine (0.2040), days to first fruit harvest (0.2809) and average fruit weight (0.2171). Fruit diameter (-0.4453) and flesh thickness (-0.3948) had negative and significant correlation. While, number of fruits per vine (-0.1344) and fruit length (-0.1944) were negatively and non-significantly correlated.

#### 4.2.2.8 Days to first female flowering

At both one and five per cent level of significance, days to 50 per cent flowering (0.5221) had positive and significant association. While, positive and non-significant association was observed with days to first fruit harvest (0.2126) and average fruit weight (0.2829). Number of male flower (-0.3070), number of female flowers (-0.3177) and fruit diameter (-0.3217) had negative and significant correlation with days to first female flowering. Whereas, number of fruits per vine (-0.2213) and flesh thickness (-0.1939) were negatively and non-significantly associated.

#### 4.2.2.9 Days to 50 per cent flowering

Days to 50 per cent flowering (both at 1% and 5% level of significance) was negatively and significantly correlated with number of male flowers (-0.4338) and flesh thickness (-0.3226). While, traits like number of female flowers per vine (-0.2564), number of fruits per vine (-0.1873) and fruit diameter (-0.1825) were negatively and

non-significantly correlated. Average fruit weight (0.1674), days to first fruit harvest (0.0793) and fruit length (0.0355) were positively and non-significantly correlated.

#### **4.2.2.10 Number of male flowers per vine**

Number of male flowers (both at 1% and 5% level of significance) had positive and significant association with sex ratio (0.4899) and fruit diameter (0.4443). While, non-significant positive association was found with traits like number of female flowers (0.0836), fruit length (0.1476) and flesh thickness (0.2226). Days to first fruit harvest (-0.1618), number of fruits per vine (-0.1325) and average fruit weight (-0.0333) were negatively and non-significantly correlated.

#### **4.2.2.11 Number of female flowers per vine**

Number of female flowers per vine (0.819) at both one and five per cent level of significance has positive and significant association with number of fruits per vine (0.8134). While, positive and non-significant association was observed for fruit length (0.0267) and fruit diameter (0.0735). Negative and significant association was observed for sex ratio (-0.7099) and days to first fruit harvest (-0.3865). Whereas, average fruit weight (-0.2108) and flesh thickness (-0.0384) were negatively and non-significantly correlated.

#### **4.2.2.12 Sex ratio**

Sex ratio (both at 1% and 5% level of significance) was positively and non-significantly associated with days to first fruit harvest (0.2053), fruit length (0.1158), fruit diameter (0.1943) and flesh thickness (0.1045). While, it was negatively and highly significantly correlated with number of fruits per vine (-0.6742). Average fruit weight (0.1331) was negatively and non-significantly correlated.

#### **4.2.2.13 Days to first fruit harvest**

Days to first fruit harvest (both at 1% and 5% level of significance) was positively and non-significantly associated with fruit length (0.1456). Number of fruits per vine (-0.3968) and average fruit weight (-0.3589) were negatively and significantly

**Table 6. Phenotypic correlation coefficient between different yield components in cucumber genotypes**

Traits	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19
X1	1.0000	0.2901	-0.0648	0.2184	0.1881	-0.1772	-0.2463	-0.4298**	-0.2949	0.3679*	0.1318	0.0650	-0.1065	0.0703	-0.1799	-0.0552	0.3476*	0.1330	0.0643
X2		1.0000	0.0764	-0.0336	0.0234	-0.2207	-0.0510	-0.1737	-0.3333*	0.6899**	0.1557	0.2917	-0.3165*	0.1114	0.0507	-0.0300	0.3965**	0.1317	0.1784
X3			1.0000	-0.1392	-0.0921	-0.1744	-0.2712	-0.1695	-0.2586	-0.0837	0.1760	-0.1474	-0.1838	0.3525*	0.0377	0.1981	-0.0067	0.2332	0.2875
X4				1.0000	0.1472	0.0574	0.1991	0.1628	0.3092	0.1033	0.3333*	-0.2400	0.0373	0.0912	-0.3558**	-0.1729	-0.2317	-0.1325	-0.2067
X5					1.0000	0.3797*	0.1421	0.1574	-0.0941	0.1503	-0.2663	0.2578	0.2238	-0.4200**	-0.3083*	0.0490	0.0228	0.2378	-0.2712
X6						1.0000	0.3133*	0.4385**	0.1406	-0.1686	-0.2800	0.0667	0.3818*	-0.3775*	-0.2467	0.0772	0.0002	0.0683	-0.1743
X7							1.0000	0.6388**	0.3225*	0.2040	-0.0926	-0.0307	0.2809	-0.1344	0.2171	-0.1944	-0.4453**	-0.3948**	0.1058
X8								1.0000	0.5221**	-0.3070*	-0.3177*	0.0957	0.2126	-0.2213	0.2829	0.0221	-0.3217*	-0.1939	-0.0832
X9									1.0000	-0.4338**	-0.2564	-0.0015	0.0793	-0.1873	0.1674	0.0355	-0.1825	-0.3226*	-0.2573
X10										1.0000	0.0836	0.4899**	-0.1618	-0.1325	-0.0333	0.1476	0.4443**	0.2226	-0.0391
X11											1.0000	-0.7099**	-0.3865*	0.8134**	-0.2108	0.0267	0.0735	-0.0384	0.4036**
X12												1.0000	0.2053	-0.6742**	-0.1331	0.1158	0.1943	0.1045	-0.4347**
X13													1.0000	-0.3968**	-0.3589**	0.1456	-0.0272	-0.0447	-0.0067
X14														1.0000	-0.1123	-0.0491	-0.0133	-0.0422	0.4880**
X15															1.0000	0.3737*	0.1930	0.0193	0.5067**
X16																1.0000	0.1740	0.1343	0.1949
X17																	1.0000	0.4255**	0.0155
X18																		1.0000	0.0647
X19																			1.0000

Critical r value 1%= 0.3931 5%= 0.3043

X1= Vine length, X2= Number of leaves per vine, X3= Number of branches per vine, X4= Number of nodes per vine, X5= Node at 1<sup>st</sup> male flowering, X6= Node at 1<sup>st</sup> female flowering, X7= Days to 1<sup>st</sup> male flowering, X8= Days to 1<sup>st</sup> female flowering, X9= Days to 50% flowering, X10= Number of male flowers, X11= Number of female flowers, X12= Sex ratio, X13= Days to 1<sup>st</sup> fruit harvest, X14= Number of fruits per vine, X15= Average fruit weight, X16= Fruit length, X17= Fruit diameter, X18= Flesh thickness, X19= Fruit yield per vine.

correlated. Whereas, fruit diameter (-0.0272) and flesh thickness (-0.0447) showed negative non-significant association.

#### **4.2.2.14 Number of fruits per vine**

Number of fruits per vine showed negative and non-significant association with traits like average fruit weight (-0.1123), fruit length (-0.0491), fruit diameter (-0.0133) and flesh thickness (-0.0422).

#### **4.2.2.15 Average fruit weight (g)**

At five per cent level of significance, average fruit weight showed positive and significant correlation with fruit length (0.3737) and positive non-significant association was observed with fruit diameter (0.1930) and flesh thickness (0.0193).

#### **4.2.2.16 Fruit length (cm)**

Fruit length had positive non-significant correlation with fruit diameter (0.1740) and flesh thickness (0.1343).

#### **4.2.2.17 Fruit diameter (cm)**

Fruit diameter was positively and significantly correlated with flesh thickness (0.4255) at one per cent level of significance.

### **4.2.3 Genotypic correlation coefficient between different yield components in cucumber genotypes**

#### **4.2.3.1 Vine length (cm)**

Number of leaves per vine (0.3520), number of male flowers per vine (0.4096) and fruit diameter (0.4644) were positively and significantly associated with vine length. Number of nodes per vine (0.1512), node at which first male flower appear (0.2071), number of female flowers per vine (0.1498), sex ratio (0.0772), number of fruits per vine (0.0574) and flesh thickness (0.2795) were positively and non-significantly correlated. Whereas, days to first male flowering (-0.3916), days to first female flowering (-0.6066) and days to 50 per cent flowering (-0.5564) were negatively

and significantly associated with vine length at one and five per cent level of significance. While, number of branches per vine (-0.0545), node at first female flower (-0.1668), days to first fruit harvest (-0.1926), average fruit weight (-0.1974) and fruit length (-0.0610) showed negative non-significant correlation.

#### **4.2.3.2 Number of leaves per vine**

Number of male flowers per vine (0.7723), sex ratio (0.3305) and fruit diameter (0.4635) were positively and significantly associated with number of leaves per vine. Number of branches per vine (0.0761), node at first male flowering (0.0437), number of female flowers (0.1829), number of fruits per vine (0.1183), average fruit weight (0.0520) and flesh thickness (0.2160) were positive and non-significantly correlated. Whereas, days to 50 per cent flowering (-0.5387) and days to first fruit harvest (-0.3976) at both one and five per cent level of significance were negatively and significantly associated. While, traits like number of nodes per vine (-0.0198), node at first female flower (-0.2818), days to first male flowering (-0.0919), days to first female flowering (-0.2314) and fruit length (-0.0169) were negatively and non-significantly associated.

#### **4.2.3.3 Number of branches per vine**

At both one and five per cent level of significance, number of branches per vine had positive and significant correlation with number of fruits per vine (0.3725) and flesh thickness (0.5411). Node at first male flower (0.0528), number of female flowers (0.1824), average fruit weight (0.0390), fruit length (0.3034) and fruit diameter (0.1204) were positively and non-significantly correlated. Days to first male flower (-0.4197) was negatively and significantly correlated. While, negative and non-significant correlation was observed for number of nodes per vine (-0.1166), node at first female flower (-0.1603), days to first female flower (-0.1039), days to 50 per cent flowering (-0.1902), number of male flowers per vine (-0.1591), sex ratio (-0.2838) and days to first fruit harvest (-0.2146).

#### **4.2.3.4 Number of nodes per vine**

Number of female flowers per vine (0.4252) had positive and significant association with number of nodes per vine. Node at first female flower (0.1502), days to

first male flowering (0.2614), days to first female flowering (0.0809), days to 50 per cent flowering (0.0814), number of male flowers (0.2061) and number of fruits per vine (0.1399) had positive and non-significant correlation. Whereas, days to first fruit harvest (-0.3555), average fruit weight (-0.4508), fruit length (-0.3152) and fruit diameter (-0.4862) showed negative and significant correlation at one and five per cent level of significance. While, sex ratio (-0.2845) and flesh thickness (-0.2264) showed negative and non-significant association.

#### **4.2.3.5 Node at first male flower appearance**

Node at which first male flower appears had positive and significant association with node at first female flower (0.3635) and sex ratio (0.4493). While, number of male flowers (0.2305), days to first fruit harvest (0.1639) and flesh thickness (0.1172) were positively and non-significantly correlated. Days to 50 per cent flowering (-0.4083), number of female flowers (-0.3989), number of fruits per vine (-0.4977) and average fruit weight (-0.4827) had negative and significant correlation at one and five per cent level of significance. Traits like, days to first male flowering (-0.0548), days to first female flowering (-0.0742), fruit length (-0.0891) and fruit diameter (-0.2070) showed negative and non-significant correlation.

#### **4.2.3.6 Node at first female flowering**

At both one and five per cent level of significance, days to first male flowering (0.4140) and days to first female flowering (0.6704) had positive and significant association with node at first female flowering. Days to 50 per cent flowering (0.2889), sex ratio (0.2032), days to first fruit harvest (0.7058), average fruit weight (0.2804), fruit length (0.0720) and flesh thickness (0.0069) showed positive and non-significant association. Whereas, number of female flowers (-0.3304) and number of fruits per vine (-0.4207) showed negative and significant correlation. Whereas, number of male flowers (-0.1663) and fruit diameter (-0.1179) were negatively and non-significantly correlated.

#### **4.2.3.7 Days to first male flowering**

Days to first male flowering had positive and significant correlation with days to first female flowering (0.9982) and days to 50 per cent flowering (0.5820). Days to first

fruit harvest (0.1867) and average fruit weight (0.2092) were positively and non-significantly correlated. Whereas, number of female flowers per vine (-0.3239), fruit length (-0.3541), fruit diameter (-0.7726) and flesh thickness (-0.6912) have negative and significant correlation at one and five per cent level of significance. Number of female flowers per vine (-0.0609), sex ratio (-0.0609) and number of fruits per vine (-0.1226) showed negative and non-significant correlation.

#### **4.2.3.8 Days to first female flowering**

At both one and five per cent level of significance days to first female flowering had positive and significant correlation with days to 50 per cent flowering (0.8955) and average fruit weight (0.3320). While, sex ratio (0.1186) and days to first fruit harvest (0.2908) were positively and non-significantly correlated. Number of male flowers per vine (-0.3631), number of fruits per vine (-0.3493), fruit diameter (-0.7725) and flesh thickness (-0.5783) were negatively and significantly correlated. Negative and non-significant association was found with fruit length (-0.0836) and significant negative association with number female flowers (-0.4218).

#### **4.2.3.9 Days to 50 per cent flowering**

Days to 50 per cent flowering had negative and significant correlation with number of male flowers per vine (-0.6571), number of female flowers per vine (-0.3981), fruit diameter (-0.5807) and flesh thickness (-0.9985) at both one and five per cent level of significance. While, number of fruits per vine (-0.2257) and fruit length (-0.0882) were negatively and non-significantly correlated. Days to first fruit harvest (0.1967), average fruit weight (0.1922) and sex ratio (0.0615) were positively and non-significantly correlated.

#### **4.2.3.10 Number of male flowers per vine**

Number of male flowers has positive and significant association with sex ratio (0.4804), fruit diameter (0.5992) and flesh thickness (0.3116) at one and five per cent level of significance. Number of female flowers per vine (0.1104) and fruit length (0.1573) showed positive and non-significant correlation. Days to first fruit harvest (-0.2808), number of fruits per vine (-0.1422) and average fruit weight (-0.0453) were negatively and non-significantly correlated.

#### **4.2.3.11 Number of female flowers per vine**

Number of fruits per vine (0.8821) was positively correlated with number of female flowers per vine. Fruit length (0.0017) and fruit diameter (0.0367) were positively and non-significantly correlated. Sex ratio (-0.7921) and days to first fruit harvest (-0.7793) were negatively and significantly correlated (both at 1% and 5% level of significance). Traits like average fruit weight (-0.2600) and flesh thickness (-0.0827) were negatively and non-significantly correlated.

#### **4.2.3.12 Sex ratio**

At one per cent level of significance, days to first fruit harvest (0.4377), fruit diameter (0.3906) and flesh thickness (0.3211) exhibited positive and significant correlation. While, average fruit weight (0.0940) and fruit length (0.1636) were positively and non-significantly correlated. Number of fruits per vine (-0.8392) was negatively and significantly correlated.

#### **4.2.3.13 Days to first fruit harvest**

At both one and five per cent level of significance, average fruit weight (0.5666) and number of fruits per vine (-0.5857) had positive and significant correlation with days to first fruit harvest. While, fruit length (0.1682) was positively and non-significantly correlated. Fruit diameter (-0.2690) and flesh thickness (-0.1151) were negatively and non-significantly correlated.

#### **4.2.3.14 Number of fruits per vine**

Average fruit weight (-0.1172) and fruit length (-0.0380) had negative and non-significant correlation. While, fruit diameter (0.0213) and flesh thickness (0.0128) were positively and non-significantly correlated.

#### **4.2.3.15 Average fruit weight (g)**

Fruit length showed positive and significant correlation with (0.4286) average fruit weight at one per cent level of significance. While, fruit diameter (0.2266) showed positive and non-significant correlation. Flesh thickness was negatively and non-significantly correlated (-0.0731).

**Table 7. Genotypic correlation coefficients between different yield components in cucumber genotypes**

Traits	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19
X1	1.0000	0.3520*	-0.0545	0.1512	0.2071	-0.1668	-0.3916*	-0.6066**	-0.5564**	0.4096**	0.1498	0.0772	-0.1926	0.0574	-0.1974	-0.0610	0.4644**	0.2795	0.0882
X2		1.0000	0.0761	-0.0198	0.0437	-0.2818	-0.0919	-0.2314	-0.5387**	0.7723**	0.1829	0.3305*	-0.3976**	0.1183	0.0520	-0.0169	0.4635**	0.2160	0.1910
X3			1.0000	-0.1166	0.0528	-0.1603	-0.4197**	-0.1039	-0.1902	-0.1591	0.1824	-0.2838	-0.2146	0.3725*	0.0390	0.3034	0.1204	0.5411**	0.3707*
X4				1.0000	-0.0482	0.1502	0.2614	0.0809	0.0814	0.2061	0.4252*	-0.2845	-0.3555*	0.1399	-0.4508**	-0.3152*	-0.4862**	-0.2264	-0.2711
X5					1.0000	0.3635*	-0.0548	-0.0742	-0.4083*	0.2305	-0.3989**	0.4493**	0.1639	-0.4977**	-0.4827**	-0.0891	-0.2070	0.1172	-0.4129**
X6						1.0000	0.4140**	0.6704**	0.2889	-0.1663	-0.3304*	0.2032	0.7058	-0.4207**	0.2804	0.0720	-0.1179	0.0069	-0.2657
X7							1.0000	0.9982**	0.5820**	-0.3239*	-0.2884	-0.0609	0.1867	-0.1226	0.2092	-0.3541*	-0.7726**	-0.6912**	0.0731
X8								1.0000	0.8955**	-0.3631**	-0.4218**	0.1186	0.2908	-0.3493*	0.3320*	-0.0836	-0.7725**	-0.5783**	-0.2328
X9									1.0000	-0.6571**	-0.3981**	0.0615	0.1967	-0.2257	0.1922	-0.0882	-0.5807**	-0.9985**	-0.5524**
X10										1.0000	0.1104	0.4804**	-0.2808	-0.1422	-0.0453	0.1573	0.5992**	0.3116*	-0.0192
X11											1.0000	-0.7921**	-0.7793**	0.8821**	-0.2600	0.0017	0.0367	-0.0827	0.4323**
X12												1.0000	0.4377**	-0.8392**	0.0940	0.1636	0.3906*	0.3211*	-0.4902**
X13													1.0000	-0.5857**	0.5666**	0.1682	-0.2690	-0.1151	-0.1055
X14														1.0000	-0.1172	-0.0380	0.0213	0.0128	0.5218**
X15															1.0000	0.4286**	0.2266	-0.0713	0.5581**
X16																1.0000	0.0947	0.0478	0.1904
X17																	1.0000	0.3973**	-0.0514
X18																		1.0000	0.0438
X19																			1.0000

Critical r value at 1%= 0.3931 5%= 0.3043

X1= Vine length(cm), X2= Number of leaves, X3= Number of branches, X4= Number of nodes, X5= Node at 1<sup>st</sup> male flowering, X6= Node at 1<sup>st</sup> female flowering, X7= Days to 1<sup>st</sup> male flowering, X8= Days to 1<sup>st</sup> female flowering, X9= Days to 50% flowering, X10= Number of male flowers. X11= Number of female flowers, X12= Sex ratio, X13= Days to 1<sup>st</sup> fruit harvest, X14= Number of fruits per vine, X15= Average fruit weight, X16= Fruit length, X17= Fruit diameter, X18= Flesh thickness, X19= Fruit yield per vine.

#### **4.2.3.16 Fruit length (cm)**

Fruit diameter (0.0947) and flesh thickness (0.0478) were positively and non-significantly correlated with fruit length.

#### **4.2.3.17 Fruit diameter (cm)**

Flesh thickness (0.3973) was positively and significantly correlated with fruit diameter at one per cent level of significance.

### **4.3 Path coefficient analysis**

The result of path coefficients gives relative contribution of different characters towards fruit yield. By partitioning the genotypic and phenotypic correlations, the direct effect of chosen trait on fruit yield per vine and its indirect effects through other characters are computed and presented in Table 8 and Table 9.

#### **4.3.1 Phenotypic path analysis**

##### **4.3.1.1 Vine length (cm)**

Vine length had positive direct effect (0.1979) and was positively associated with fruit yield per vine ( $r_P = 0.0643$ ). Positive indirect effect was observed through number of male flowers (0.0587), node at female flower (0.0461), number of leaves per vine (0.0413), days to 50 per cent flowering (0.0545), node at first male flowering (0.0280), number of female flowers per vine (0.0144), number of fruits per vine (0.0047), flesh thickness (0.0099) and fruit length (0.0001). Negative indirect effect was seen through average fruit weight (-0.1182), fruit diameter (-0.0939), number of nodes per vine (-0.0637), sex ratio (-0.0390), days to first male flowering (-0.0137), days to first fruit harvest (-0.0107) and days to first female flowering (-0.0482).

##### **4.3.1.2 Number of leaves per vine**

Number of leaves per vine had positive direct effect (0.1423) and was positively associated with fruit yield per vine ( $r_P = 0.1784$ ). Positive indirect effect was seen through number of male flowers per vine (0.1102), days to 50 per cent flowering

(0.0545), node at first female flower (0.0575), average fruit weight (0.3333), number of fruits per vine (0.0075), vine length (0.0574), number of female flowers (0.0170), node at first male flower (0.0035), number of nodes per vine (0.0098), flesh thickness (0.0098) and number of branches per vine (0.0046). Whereas, negative indirect effect was observed through sex ratio (-0.1748), fruit diameter (-0.1071), days to first fruit harvest (-0.0318), days to first male flowering (-0.0028) and days to first female flowering (-0.0195).

#### **4.3.1.3 Number of branches per vine**

Number of branches per vine had positive direct effect (0.0607) and was positively associated with fruit yield per vine ( $rP=0.2875$ ). Positive indirect effect was observed through number of leaves per vine (0.0109), number of nodes per vine (0.0406), node at first female flower (0.0454), days to 50 per cent flowering (0.0478), number of female flowers (0.0192), sex ratio (0.0883), number of fruits per vine (0.0236), average fruit weight (0.0248), fruit diameter (0.0018) and flesh thickness (0.0174). Whereas, negative indirect effect was seen through vine length (-0.0128), node at first male flower (-0.0137), days to first male flower (-0.0151), days to first female flower (-0.0190), number of male flowers (-0.0134), days to first harvest (-0.0185) and fruit length (-0.0003).

#### **4.3.1.4 Number of nodes per vine**

Number of nodes per vine had negative direct effect (-0.2915) and was negatively associated with fruit yield per vine ( $rP=-0.2067$ ). Positive indirect effect was contributed through sex ratio (0.1439), fruit diameter (0.0626), number of female flowers per vine (0.0363), number of male flowers per vine (0.0165), number of fruits per vine (0.0061), node at first male flower (0.0219), vine length (0.0432), days to first male flowering (0.0111), days to first female flowering (0.0182) and days to first fruit harvest (0.0038). Negative indirect effect was seen through average fruit weight (-0.2339), node at first female flower (-0.0150), flesh thickness (-0.0099), number of branches per vine (-0.0085), days to 50 per cent flowering (-0.0072) and number of leaves per vine (-0.0048).

#### 4.3.1.5 Node at first male flower appearance

Node at first male flower appearance had positive direct effect (0.1490) and was negatively associated with fruit yield per vine ( $rP=-0.2712$ ). Positive indirect effect was seen through number of male flowers (0.0240), days to first female flowering (0.0176), days to 50 per cent flowering (0.0174), days to first male flowering (0.0079), number of leaves per vine (0.0033), vine length (0.0372), days to first fruit harvest (0.0225) and flesh thickness (0.0177). Whereas, negative indirect effect was contributed through sex ratio (-0.1545), average fruit weight (-0.2026), number of fruits per vine (-0.0281), node at first female flowering (-0.0989), number of female flowers (-0.0290), number of seeds per fruit (-0.0233), number of nodes per vine (-0.0429) and number of branches per vine (-0.0056).

#### 4.3.1.6 Node at first female flower

Node at first female flower had negative direct effect (-0.2604) and was negatively associated with fruit yield per vine ( $rP=-0.1743$ ). Negative indirect effect was contributed through number of fruits per vine (-0.0253), sex ratio (-0.0400), number of leaves per vine (-0.0314), number of female flowers (-0.0305), number of male flowers (-0.0269), days to 50 per cent flowering (-0.0260), vine length (-0.0351), number of nodes per vine (-0.0167), number of branches per vine (-0.0106) and flesh thickness (-0.0012). While, positive indirect effect was seen through average fruit weight (0.1621), node at first male flower appear (0.0566), days to first male flowering (0.0175), days to first female flowering (0.0491), days to first fruit harvest (0.0384) and flesh thickness (0.0051).

#### 4.3.1.7 Days to first male flowering

Days to first male flowering (0.0557) had positive direct effect and was positively associated with fruit yield per vine ( $rP=0.1058$ ). Positive indirect effect was seen through average fruit weight (0.1427), fruit diameter (0.1375), days to first female flowering (0.0716), node at first male flower (0.1203), sex ratio (0.0184) and days to first fruit harvest (0.0282). Whereas, negative indirect effect was contributed through node at first male flowering (0.0212), node at first female flower (-0.0816), days to 50

per cent flowering (-0.0595), number of male flowers (-0.0326), number of fruits per vine (-0.0090), number of nodes per vine (-0.0580), vine length (-0.0488), number of branches per vine (-0.0165), number of female flowers per vine (-0.0101), number of leaves per vine (-0.0073) and flesh thickness (-0.0294).

#### **4.3.1.8 Days to first female flowering**

Days to first female flowering (0.1121) had positive direct effect and was negatively associated with fruit yield per vine ( $rP=-0.0832$ ). Positive indirect effect was contributed through average fruit weight (0.1859), fruit diameter (0.0869), days to first male flowering (0.0356), node at male flower appear (0.0235) and days to first fruit harvest (0.0214). While, negative indirect effect was seen through node at female flower appear (-0.1142), sex ratio (-0.1215), days to 50 per cent flowering (-0.0964), number of male flowers per vine (-0.0490), number of female flowers per vine (-0.0346), number of fruits per vine (-0.0148), number of leaves per vine (-0.0247), vine length (-0.0851), number of nodes per vine (-0.0474), flesh thickness (-0.0144) and number of branches per vine (-0.0103).

#### **4.3.1.9 Days to 50 per cent flowering**

Days to 50 per cent flowering had negative and direct effect (-0.1846) and was negatively associated with fruit yield per vine ( $rP=-0.2573$ ). Negative indirect effect was observed through number of male flowers per vine (-0.0693), number of leaves per vine (-0.0474), number of female flowers per vine (-0.0279), number of branches per vine (-0.0157), number of nodes per vine (-0.0114), number of fruits per vine (-0.0125), node at female flower appear (-0.0366), flesh thickness (-0.0240), node at first male flowering (-0.0140) and vine length (-0.0584). Whereas, positive indirect effect was contributed through average fruit weight (0.1100), fruit diameter (0.0493), days to first male flowering (0.0180), days to first female flowering (0.0585) and days to first fruit harvest (0.0080).

#### **4.3.1.10 Number of male flowers per vine**

Number of male flowers per vine had positive direct effect (0.1597) and was negatively associated with fruit yield per vine ( $rP=-0.0391$ ). Positive indirect effect was seen through number of leaves per vine (0.0982), days to 50 per cent flowering

**Table 8. Phenotypic direct (diagonal) and indirect effects of different yield related traits in cucumber genotypes**

Traits	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	rP
<b>X1</b>	<b>0.1979</b>	0.0413	-0.0039	-0.0637	0.0280	0.0461	-0.0137	-0.0482	0.0545	0.0587	0.0144	-0.0390	-0.0107	0.0047	-0.1182	0.0001	-0.0939	0.0099	0.0643
<b>X2</b>	0.0574	<b>0.1423</b>	0.0046	0.0098	0.0035	0.0575	-0.0028	-0.0195	0.0615	0.1102	0.0170	-0.1748	-0.0318	0.0075	0.3333	0.0000	-0.1071	0.0098	0.1784
<b>X3</b>	-0.0128	0.0109	<b>0.0607</b>	0.0406	-0.0137	0.0454	-0.0151	-0.0190	0.0478	-0.0134	0.0192	0.0883	-0.0185	0.0236	0.0248	-0.0003	0.0018	0.0174	0.2875
<b>X4</b>	0.0432	-0.0048	-0.0085	<b>-0.2915</b>	0.0219	-0.0150	0.0111	0.0182	-0.0072	0.0165	0.0363	0.1439	0.0038	0.0061	-0.2339	0.0003	0.0626	-0.0099	-0.2067
<b>X5</b>	0.0372	0.0033	-0.0056	-0.0429	<b>0.1490</b>	-0.0989	0.0079	0.0176	0.0174	0.0240	-0.0290	-0.1545	0.0225	-0.0281	-0.2026	-0.0001	-0.0062	0.0177	-0.2712
<b>X6</b>	-0.0351	-0.0314	-0.0106	-0.0167	0.0566	<b>-0.2604</b>	0.0175	0.0491	-0.0260	-0.0269	-0.0305	-0.0400	0.0384	-0.0253	0.1621	-0.0001	0.0000	0.0051	-0.1743
<b>X7</b>	-0.0488	-0.0073	-0.0165	-0.0580	0.0212	-0.0816	<b>0.0557</b>	0.0716	-0.0595	-0.0326	-0.0101	0.0184	0.0282	-0.0090	0.1427	0.0003	0.1203	-0.0294	0.1058
<b>X8</b>	-0.0851	-0.0247	-0.0103	-0.0474	0.0235	-0.1142	0.0356	<b>0.1121</b>	-0.0964	-0.0490	-0.0346	-0.0575	0.0214	-0.0148	0.1859	0.0000	0.0869	-0.0144	-0.0832
<b>X9</b>	-0.0584	-0.0474	-0.0157	-0.0114	-0.0140	-0.0366	0.0180	0.0585	<b>-0.1846</b>	-0.0693	-0.0279	0.0009	0.0080	-0.0125	0.1100	-0.0001	0.0493	-0.0240	-0.2573
<b>X10</b>	0.0728	0.0982	-0.0051	-0.0301	0.0224	0.0439	-0.0114	-0.0344	0.0801	<b>0.1597</b>	0.0091	-0.2936	-0.0163	-0.0089	-0.0219	-0.0002	-0.1200	0.0166	-0.0391
<b>X11</b>	0.0261	0.0222	0.0107	-0.0971	-0.0397	0.0729	-0.0052	-0.0356	0.0473	0.0133	<b>0.1090</b>	0.4225	-0.0389	0.0544	-0.1386	0.0000	-0.0199	-0.0029	0.4036**
<b>X12</b>	0.0129	0.0415	-0.0089	0.0700	0.0384	-0.0174	-0.0017	0.0107	0.0003	0.0782	-0.0774	<b>-0.5994</b>	0.0206	-0.0451	0.0875	-0.0002	-0.0525	0.0078	-0.4347**
<b>X13</b>	-0.0211	-0.0450	-0.0112	-0.0109	0.0333	-0.0994	0.0157	0.0238	-0.0146	-0.0258	-0.0421	-0.1230	<b>0.1006</b>	-0.0265	0.2359	-0.0002	0.0073	-0.0033	-0.0067
<b>X14</b>	0.0139	0.0158	0.0214	-0.0266	-0.0626	0.0983	-0.0075	-0.0248	0.0346	-0.0212	0.0886	0.4041	-0.0399	<b>0.0669</b>	-0.0738	0.0001	0.0036	-0.0031	0.4880**
<b>X15</b>	-0.0356	0.0072	0.0023	0.1037	-0.0459	-0.0642	0.0121	0.0317	-0.0309	-0.0053	-0.0230	-0.0798	0.0361	-0.0075	<b>0.6572</b>	-0.0006	-0.0521	0.0014	0.5067**
<b>X16</b>	-0.0109	-0.0043	0.0120	0.0504	0.0073	-0.0210	-0.0108	0.0025	-0.0066	0.0236	0.0029	-0.0694	0.0146	-0.0033	0.2456	<b>-0.0017</b>	-0.0470	0.0100	0.1949
<b>X17</b>	0.0688	0.0564	-0.0004	0.0675	0.0034	0.0000	-0.0248	-0.0360	0.0337	0.0710	0.0080	-0.1165	-0.0027	-0.0009	0.1269	-0.0003	<b>-0.2701</b>	0.0317	0.0155
<b>X18</b>	0.0263	0.0187	0.0142	0.0386	0.0354	-0.0178	-0.0220	-0.0217	0.0596	0.0355	-0.0042	-0.0626	-0.0045	-0.0028	0.0127	-0.0002	-0.1149	<b>0.0744</b>	0.0647

**Residual value: 0.367**

X1= Vine length, X2= Number of leaves per vine, X3= Number of branches per vine, X4= Number of nodes per vine, X5= Node at 1<sup>st</sup> male flowering, X6= Node at 1<sup>st</sup> female flowering, X7= Days to 1<sup>st</sup> male flowering, X8= Days to 1<sup>st</sup> female flowering, X9= Days to 50% flowering, X10= Number of male flowers, X11= Number of female flowers, X12= Sex ratio, X13= Days to 1<sup>st</sup> fruit harvest, X14= Number of fruits per vine, X15= Average fruit weight, X16= Fruit length, X17= Fruit diameter, X18= Flesh thickness, rP= Phenotypic correlation coefficient of fruit yield per vine.

(0.0801), node at first female flower appear (0.0439), flesh thickness (0.0166), node at first male flower (0.0224), vine length (0.0728) and number of female flowers (0.0091). Negative indirect effect was seen through sex ratio (-0.2936), fruit diameter (-0.1200), number of fruits per vine (-0.0089), number of nodes per vine (-0.0301), average fruit weight (-0.0219), days to first male flowering (-0.0114), days to first female flowering (-0.0344), days to first fruit harvest (-0.0163) and number of branches per vine (-0.0051).

#### **4.3.1.11 Number of female flowers per vine**

Number of female flowers per vine (0.1090) had positive direct effect and was positively associated with fruit yield per vine ( $rP=0.4036$ ). Positive indirect effect was seen through sex ratio (0.4225), node at first female flower (0.0729), number of fruits per vine (0.0544), days to 50 per cent flowering (0.0473), number of leaves per vine (0.0222), number of male flowers per vine (0.0133), number of branches per vine (0.0107) and vine length (0.0261). Whereas, negative indirect effect was seen through average fruit weight (-0.1386), number of node per vine (-0.0971), node at first male flowering (-0.0397), days to first fruit harvest (-0.0389), days to first female flowering (-0.0356), fruit diameter (-0.0199) and days to first male flowering (-0.0052).

#### **4.3.1.12 Sex ratio**

Sex ratio had negative direct effect (-0.5994) and was negatively associated with fruit yield per vine ( $rP=-0.4347$ ). Positive indirect effect was seen through average fruit weight (0.0875), number of male flowers per vine (0.0782), number of nodes per vine (0.0700), number of leaves per vine (0.0415), node at first male flower (0.0384), days to first fruit harvest (0.0206), days to first female flowering (0.0107) and vine length (0.0129). Negative indirect effect was seen through number of fruits per vine (-0.1798), number of female flowers (-0.0774), fruit diameter (-0.0525), number of fruits per vine (-0.0451) and node at first female flower (-0.0174).

#### **4.3.1.13 Days to first fruit harvest**

Days to first fruit harvest (0.1006) had positive direct effect and was negatively associated with fruit yield per vine ( $rP=-0.0067$ ). Negative indirect effect was seen

through sex ratio (-0.1230), node at first female flower (-0.0994), number of female flowers per vine (-0.0421), number of fruits per vine (-0.0265), number of male flowers per vine (-0.0258), vine length (-0.0211), number of nodes per vine (-0.0109), days to 50 per cent flowering (-0.0146) and number of branches per vine (-0.0112). Positive indirect effect was contributed through average fruit weight (0.2359), node at first male flower (0.0333), days to first female flowering (0.0238) and days to first male flowering (0.0157).

#### **4.3.1.14 Number of fruits per vine**

Number of fruits per vine had positive direct effect (0.0669) and was positively associated with fruit yield per vine ( $rP=0.4880$ ). Positive indirect effect was seen through sex ratio (0.4041), node at first female flower (0.0983), number of female flowers per vine (0.0886), days to 50 per cent flowering (0.0346), number of leaves per vine (0.0158), number of branches per vine (0.0214), fruit diameter (0.0036) and vine length (0.0139). While, negative indirect effect was seen through average fruit weight (-0.0738), node at first male flower (-0.0626), days to first female flowering (-0.0248), number of male flowers per vine (-0.0212), number of node per vine (-0.0266), days to first fruit harvest (-0.0399), days to first male flowering (-0.0075) and flesh thickness (-0.0031).

#### **4.3.1.15 Average fruit weight (g)**

Average fruit weight had positive direct effect (0.6572) and was positively associated with fruit yield per vine ( $rP=0.5067$ ). Negative indirect effect was seen through sex ratio (-0.0798), node at first female flower (-0.0642), fruit diameter (-0.0521), node at first male flower (-0.0459), days to 50 per cent flowering (-0.0309), number of female flowers per vine (-0.0230), number of fruits per vine (-0.0075), number of male flowers per vine (-0.0053), fruit length (-0.0006) and vine length (-0.0356). Whereas, positive indirect effect was contributed through number of nodes per vine (0.1037), days to first male flowering (0.0121), days to first fruit harvest (0.0361), days to first female flowering (0.0317), number of leaves per vine (0.0072), number of branches per vine (0.0023) and flesh thickness (0.0014).

#### 4.3.1.16 Fruit length (cm)

Fruit length had negative direct effect (-0.0017) and was positively associated with fruit yield per vine ( $rP=0.1949$ ). Positive indirect effect was observed through average fruit weight (0.2456), number of male flowers per vine (0.0236), number of nodes per vine (0.0504), flesh thickness (0.0100), days to first fruit harvest (0.0146), days to first female flowering (0.0025), number of branches per vine (0.0120) and node at first male flower (0.0073). Whereas, negative indirect effect was seen through sex ratio (-0.0694), fruit diameter (-0.0470), node at first female flower (-0.0210), days to first male flowering (-0.0108), number of fruits per vine (-0.0033), number of leaves per vine (-0.0043), days to 50 per cent flowering (-0.0066) and vine length (-0.0109).

#### 4.3.1.17 Fruit diameter (cm)

Fruit diameter had negative direct effect (-0.2701) and was positively associated with fruit yield per vine ( $rP=0.0155$ ). Positive indirect effect was observed through number of male flowers per vine (0.0710), average fruit weight (0.1269), number of leaves per vine (0.0564), days to 50 per cent flowering (0.0337), number of nodes per vine (0.0675), vine length (0.0688), flesh thickness (0.0317) and node at first male flower (0.0034). Whereas, negative indirect effect was seen through sex ratio (-0.1165), days to first male flowering (-0.0248) and days to first female flowering (-0.0360).

#### 4.3.1.18 Flesh thickness (cm)

Flesh thickness had positive direct effect (0.0744) and was positively associated with fruit yield per vine ( $rP=0.0647$ ). Negative indirect effect was seen through fruit diameter (-0.1149), sex ratio (-0.0626), days to first male flowering (-0.0220), days to first female flowering (-0.0217) and node at first female flower (-0.0178). While, positive indirect effect was observed through days to 50 per cent flowering (0.0596), number of node per vine (0.0386), number of male flowers per vine (0.0355), node at first male flower (0.0354), vine length (0.0263), number of leaves per vine (0.0187), number of branches per vine (0.0142) and average fruit weight (0.0127).

### 4.3.2 Genotypic path analysis

#### 4.3.2.1 Vine length (cm)

Vine length had positive direct effect (0.0674) and was positively associated with fruit yield per vine ( $r_G=0.0882$ ). Positive indirect effect was seen through number of male flowers per vine (0.0641), number of branches per vine (0.089), number of leaves per vine (0.1971), days to first male flowering (0.0202), number of female flowers per vine (0.0842), days to 50 per cent flowering (0.1630), days to first fruit harvest (0.0036), node at first female flower (0.0423), flesh thickness (0.0532) and node at first male flower (0.0077). Whereas, negative indirect effect was seen through average fruit weight (-0.1030), sex ratio (-0.1294), number of nodes per vine (-0.0271), fruit diameter (-0.0761), number of fruits per vine (-0.0232), days to first female flowering (-0.0835) and fruit length (-0.0126).

#### 4.3.2.2 Number of leaves per vine

Number of leaves per vine had positive direct effect (0.5599) and was positively associated with fruit yield per vine ( $r_G=0.1910$ ). Positive indirect effect was observed through days to 50 per cent flowering (0.1578), average fruit weight (0.0272), days to first male flowering (0.0047), days to first fruit harvest (0.0073), node at first female flower (0.0715), node at first male flower (0.0016), number of nodes per vine (0.0035) and vine length (0.0237). Negative indirect effect was observed through number of female flowers per vine (-0.1028), sex ratio (-0.5539), days to first female flowering (-0.0319), fruit length (-0.0035), flesh thickness (-0.0411), number of branches (-0.0124), fruit diameter (-0.0759) and number of fruits per vine (-0.0478).

#### 4.3.2.3 Number of branches per vine

Number of branches per vine had negative direct effect (-0.1628) and was positively associated with fruit yield per vine ( $r_G=0.1029$ ). Positive direct effect was observed through days to 50 per cent flowering (0.0577), average fruit weight (0.0204), days to first fruit harvest (0.0040), fruit length (0.0628), number of nodes per vine (0.0209), sex ratio (0.4756), flesh thickness (0.1029), node at first female flower (0.0407), node at first male flower (0.0020), number of leaves per vine (0.0426) and days to first male flowering (0.0217). Whereas, negative indirect effect was seen

through number of female flowers per vine (-0.1025), fruit diameter (-0.0197), number of fruits per vine (-0.1505), days to first female flowering (-0.0143) and vine length (-0.0037).

#### **4.3.2.4 Number of nodes per vine**

Number of nodes per vine had negative direct effect (-0.1791) and was negatively associated with fruit yield per vine ( $rG=-0.2711$ ). Positive indirect effect was seen through number of branches per vine (0.0190), sex ratio (0.4767), number of male flowers per vine (0.0322), days to first female flowering (0.0111), vine length (0.0102), days to first fruit harvest (0.0066) and fruit diameter (0.0797). Negative indirect effect was observed through number of female flowers per vine (-0.2390), number of fruits per vine (-0.0565), average fruit weight (-0.2353), number of leaves per vine (-0.0111), fruit length (-0.0652), node at first female flower (-0.0381), days to 50 per cent flowering (-0.0238), days to first male flowering (-0.0135), flesh thickness (-0.0431) and node at first male flower (-0.0018).

#### **4.3.2.5 Node at first male flowering**

Node at first male flowering had positive direct effect (0.0374) and was negatively associated with fruit yield per vine ( $rG=-0.4129$ ). Positive indirect effect was seen through number of female flowers per vine (0.2242), days to 50 per cent flowering (0.1196), number of male flowers per vine (0.0360), fruit diameter (0.0339), number of leaves per vine (0.0245), number of fruits per vine (0.2010), flesh thickness (0.0223), vine length (0.0140), number of node per vine (0.0086) and days to first male flowering (0.0028). Whereas, negative indirect effect was seen through sex ratio (-0.7529), average fruit weight (-0.2520), node at first female flower (-0.0922), days to first female flowering (-0.0102), fruit length (-0.0184), number of branches (-0.0086) and days to first fruit harvest (-0.0030).

#### **4.3.2.6 Node at first female flowering**

Node at first female flower had negative direct effect (-0.2537) and was negatively associated with fruit yield per vine ( $rG=-0.2657$ ). Negative indirect effect

was seen through sex ratio (-0.3405), days to 50 per cent flowering (-0.0846), number of male flowers per vine (-0.0260), days to first male flowering (-0.0214), number of leaves per vine (-0.1578), number of node per vine (-0.0269) and vine length (-0.0112). While, positive indirect effect was contributed through number of female flowers per vine (0.1858), days to first fruit harvest (0.0130), average fruit weight (0.1464), days to first female flowering (0.0923), number of fruits per vine (0.1699), number of branches per vine (0.0261), fruit diameter (0.0193), node at first male flower (0.0136), flesh thickness (0.0013) and fruit length (0.0149).

#### **4.3.2.7 Days to first male flowering**

Days to first male flowering had negative direct effect (-0.0516) and was negatively associated with fruit yield per vine ( $rG=-0.0731$ ). Negative indirect effect was seen through days to 50 per cent flowering (-0.1705), flesh thickness (-0.1315), number of male flowers per vine (-0.0507), fruit length (-0.0732), number of nodes per vine (-0.0468), number of leaves per vine (-0.0515), days to first fruit harvest (-0.0034) and node at first male flower (-0.0020). Whereas, positive indirect effect was observed through number of female flowers per vine (0.1621), average fruit weight (0.1092), days to first female flowering (0.1680), sex ratio (0.1021), number of branches per vine (0.0683) and number of fruits per vine (0.0495).

#### **4.3.2.8 Days to first female flowering**

Days to first female flowering had positive direct effect (0.1377) and was negatively associated with fruit yield per vine ( $rG=-0.2328$ ). Positive indirect effect was seen through number of female flowers per vine (0.2371), average fruit weight (0.1733), number of fruits per vine (0.1411), days to first male flowering (0.0630), days to first fruit harvest (0.0054) and number of branches per vine (0.0169). Whereas, negative indirect effect was seen through number of male flowers (-0.0568), days to 50 per cent flowering (-0.2564), sex ratio (-0.1987), node at first female flower (-0.1701) and flesh thickness (-0.1100).

#### **4.3.2.9 Days to 50 per cent flowering**

Days to 50 per cent flowering had positive direct effect (0.2929) and was negatively associated with fruit yield per vine ( $rG=-0.5524$ ). Negative indirect effect

was seen through number of male flowers per vine (-0.1028), number of leaves per vine (-0.3016), sex ratio (-0.1031), node at first female flower (-0.0733), node at first male flower (-0.0153), flesh thickness (-0.2214), days to first male flowering (-0.0301), fruit length (-0.0182) and days to first fruit harvest (-0.0036). Whereas, positive indirect effect was observed through number of branches per vine (0.0310), number of female flowers (0.2238), average fruit weight (0.1003), days to first female flowering (0.1205) and number of fruits per vine (0.0912).

#### **4.3.2.10 Number of male flowers per vine**

Number of male flowers had positive direct effect (0.1564) and was negatively associated with fruit yield per vine ( $rG=-0.0192$ ). Positive indirect effect was observed through number of leaves per vine (0.4324), days to 50 per cent flowering (0.1925), flesh thickness (0.0593), number of fruits per vine (0.0574), days to first male flowering (0.0167), fruit length (0.0584), days to first fruit harvest (0.0052), node at first female flower (0.0422) and node at first male flower (0.0086). While, negative and indirect effect was seen through, sex ratio (-0.8051), number of female flowers per vine (-0.0621), number of nodes per vine (-0.0369), average fruit weight (-0.0237) and days to first female flowering (-0.0500).

#### **4.3.2.11 Number of female flowers per vine**

Number of female flowers had positive direct effect (0.5622) and was positively associated with fruit yield per vine ( $rG=0.4323$ ). Positive indirect effect was observed through days to 50 per cent flowering (0.1166), number of leaves per vine (0.1024), node at first male flower (0.0419), number of male flowers per vine (0.0173), days to first male flowering (0.0149) and days to first fruit harvest (0.0144). Whereas, negative indirect effect was seen through sex ratio (-0.8051), number of fruits per vine (-0.3563), number of branches per vine (-0.0297), average fruit weight (-0.1357), node at first female flower (-0.0838), number of nodes per vine (-0.0762), days to first female flowering (-0.0581) and flesh thickness (-0.0157).

#### **4.3.2.12 Sex ratio**

Sex ratio had negative direct effect (-1.6757) and was negatively associated with fruit yield per vine ( $rG=-0.4902$ ). Positive indirect effect was seen through number of

female flowers per vine (0.4453), number of fruits per vine (0.3390), number of nodes per vine (0.0510), average fruit weight (0.0491), number of branches per vine (0.0462), fruit length (0.0338), node at first male flower (0.0168), days to first male flowering (0.0031), number of male flowers per vine (0.0751) and days to first female flowering (0.0163). Whereas, negative indirect effect was observed through, flesh thickness (-0.0219), node at first female flower (-0.0516), days to 50 per cent flowering (-0.0180) and days to first fruit harvest (-0.0081).

#### **4.3.2.13 Days to first fruit harvest**

Days to first fruit harvest had negative direct effect (-0.0185) and was negatively associated with fruit yield per vine ( $rG=-0.1055$ ). Positive indirect effect was observed through number of female flowers per vine (0.4381), average fruit weight (0.2958), number of fruits per vine (0.2366), number of nodes per vine (0.0637), days to first female flowering (0.0400), number of branches per vine (0.0349), fruit length (0.0348) and node at first male flower (0.0061). Whereas, negative indirect effect was observed through sex ratio (-0.7335), days to 50 per cent flowering (-0.0576), node at first female flower (-0.1791), number of leaves per vine (-0.2226), days to 50 per cent flowering (-0.0576) days to first male flowering (-0.0096) and flesh thickness (-0.0219).

#### **4.3.2.14 Number of fruits per vine**

Number of fruits per vine had negative direct effect (-0.4040) and was positively associated with fruit yield per vine ( $rG=0.5218$ ). Positive indirect effect was seen through sex ratio (0.9985), number of female flowers per vine (0.4959), node at first male flower (0.0662), node at first female flower (0.1067), number of leaves per vine (0.0062), days to first male flowering (0.0274) and flesh thickness (0.0106). Whereas, negative indirect effect was seen through days to first fruit harvest (-0.2821), number of male flowers per vine (-0.2139), number of branches per vine (-0.0606), average fruit weight (-0.1228), number of nodes per vine (-0.0251), days to 50 per cent flowering (-0.0661), days to first female flowering (-0.0481) and fruit length (-0.0079).

#### **4.3.2.15 Average fruit weight (g)**

Average fruit weight had positive direct effect (0.5220) and was positively associated with fruit yield per vine ( $rG=0.5518$ ). Positive direct effect was seen through

number of female flowers (0.1462), fruit length (0.0886), days to 50 per cent flowering (0.0563), number of nodes per vine (0.0807), days to first female flowering (0.0457) and number of leaves per vine (0.0291). Whereas, negative indirect effect was seen through number of branches (-0.0063), days to first fruit harvest (-0.0105), sex ratio (-0.1575), number of fruits per vine (0.0474), node at first male flower (-0.0180), node at first female flower (-0.0711), flesh thickness (-0.0136), number of male flowers per vine (-0.0071) and days to first male flowering (-0.0108).

#### **4.3.2.16 Fruit length (cm)**

Fruit length had positive direct effect (0.2068) and was positively associated with fruit yield per vine ( $rG=0.1904$ ). Negative indirect effect was seen through number of female flowers per vine (-0.2741), number of branches per vine (-0.0494), days to first male flowering (-0.0115), node at first female flower (-0.0183), number of leaves per vine (-0.0095), vine length (-0.0041), sex ratio (-0.0031) and number of male flowers per vine (-0.0009). Whereas, positive indirect effect was seen through average fruit weight (0.2238), number of nodes per vine (0.0564), number of fruits per vine (0.0154), flesh thickness (0.0091) and days to first fruit harvest (0.0031).

#### **4.3.2.17 Fruit diameter (cm)**

Fruit diameter had negative direct effect (-0.1638) and was negatively associated with fruit yield per vine ( $rG=-0.0514$ ). Positive direct effect was seen through average fruit weight (0.1183), number of leaves per vine (0.2595), days to 50 per cent flowering (0.1701), number of male flowers per vine (0.0937), number of nodes per vine (0.0871), flesh thickness (0.0756), days to first male flowering (0.0399), vine length (0.0313), node at first female flower (0.0299), fruit length (0.0196) and days to first fruit harvest (0.0050). Whereas, negative and indirect effect was seen through, sex ratio (-0.6545), days to first female flowering (-0.1063), number of branches per vine (-0.0196), number of female flowers per vine (-0.0206) and node at first male flower (-0.0077).

#### **4.3.2.18 Flesh thickness (cm)**

Flesh thickness had positive direct effect (0.1903) and was positively associated with fruit yield per vine ( $rG=0.0438$ ). Positive indirect effect was seen through number

**Table 9. Genotypic direct (diagonal) and indirect effects of different yield related traits in cucumber genotypes**

Traits	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	rG
<b>X1</b>	<b>0.0674</b>	0.1971	0.0089	-0.0271	0.0077	0.0423	0.0202	-0.0835	0.1630	0.0641	0.0842	-0.1294	0.0036	-0.0232	-0.1030	-0.0126	-0.0761	0.0532	0.0882
<b>X2</b>	0.0237	<b>0.5599</b>	-0.0124	0.0035	0.0016	0.0715	0.0047	-0.0319	0.1578	-0.1208	-0.1028	-0.5539	0.0073	-0.0478	0.0272	-0.0035	-0.0759	0.0411	0.1910
<b>X3</b>	-0.0037	0.0426	<b>-0.1628</b>	0.0209	0.0020	0.0407	0.0217	-0.0143	0.0557	-0.0249	-0.1025	0.4756	0.0040	-0.1505	0.0204	0.0628	-0.0197	0.1029	0.3707
<b>X4</b>	0.0102	-0.0111	0.0190	<b>-0.1791</b>	-0.0018	-0.0381	-0.0135	0.0111	-0.0238	0.0322	-0.2390	0.4767	0.0066	-0.0565	-0.2353	-0.0652	0.0797	-0.0431	-0.2711
<b>X5</b>	0.0140	0.0245	-0.0086	0.0086	<b>0.0374</b>	-0.0922	0.0028	-0.0102	0.1196	0.0360	0.2242	-0.7529	-0.0030	0.2010	-0.2520	-0.0184	0.0339	0.0223	-0.4129**
<b>X6</b>	-0.0112	-0.1578	0.0261	-0.0269	0.0136	<b>-0.2537</b>	-0.0214	0.0923	-0.0846	-0.0260	0.1858	-0.3405	0.0130	0.1699	0.1464	0.0149	0.0193	0.0013	-0.2657
<b>X7</b>	-0.0264	-0.0515	0.0683	-0.0468	-0.0020	-0.1050	<b>-0.0516</b>	0.1680	-0.1705	-0.0507	0.1621	0.1021	-0.0034	0.0495	0.1092	-0.0732	0.1266	-0.1315	-0.0731
<b>X8</b>	-0.0409	-0.1296	0.0169	-0.0145	-0.0028	-0.1701	0.0630	<b>0.1377</b>	-0.2564	-0.0568	0.2371	-0.1987	0.0054	0.1411	0.1733	-0.0173	0.1266	-0.1100	-0.2328
<b>X9</b>	-0.0375	-0.03016	0.0310	-0.0146	-0.0153	-0.0733	-0.0301	0.1205	<b>0.2929</b>	-0.1028	0.2238	-0.1031	-0.0036	0.0912	0.1003	-0.0182	0.0951	-0.2214	-0.5524**
<b>X10</b>	0.0276	0.4324	0.0259	-0.0369	0.0086	0.0422	0.0167	-0.0500	0.1925	<b>0.1564</b>	-0.0621	-0.8051	0.0052	0.0574	-0.0237	0.0325	-0.0982	0.0593	-0.0192
<b>X11</b>	0.0101	0.1024	-0.0297	-0.0762	-0.0149	-0.0838	0.0149	-0.0581	0.1166	0.0173	<b>0.5622</b>	1.3273	0.0144	-0.3563	-0.1357	0.0003	-0.0060	-0.0157	0.4323**
<b>X12</b>	0.0052	0.1851	0.0462	0.0510	0.0168	-0.0516	0.0031	0.0163	-0.0180	0.0751	0.4453	<b>-1.6757</b>	-0.0081	0.3390	0.0491	0.0338	-0.0441	-0.0219	-0.4902**
<b>X13</b>	-0.0130	-0.2226	0.0349	0.0637	0.0061	-0.1791	-0.0096	0.0400	-0.0576	-0.0439	0.4381	-0.7335	<b>-0.0185</b>	0.2366	0.2958	0.0348	0.0441	-0.0219	-0.1055
<b>X14</b>	0.0039	0.0662	-0.0606	-0.0251	-0.0186	0.1067	0.0063	-0.0481	0.0661	-0.0222	-0.4959	0.9985	0.0108	<b>-0.4040</b>	0.0612	-0.0079	-0.0035	0.0024	0.5218**
<b>X15</b>	-0.0133	0.0291	-0.0063	0.0807	-0.0180	-0.0711	-0.0108	0.0457	-0.0563	-0.0071	0.1462	-0.1575	-0.0105	0.0474	<b>0.5220</b>	0.0886	-0.0371	-0.0136	0.5581**
<b>X16</b>	-0.0041	-0.0095	-0.0494	0.0564	-0.0033	-0.0183	-0.0115	0.0258	0.0246	-0.0009	-0.2741	-0.0031	0.0031	0.0154	0.2238	<b>0.2068</b>	-0.0155	0.0091	0.1904
<b>X17</b>	0.0313	0.2595	-0.0196	0.0871	-0.0077	0.0299	0.0399	-0.1063	0.1701	0.0937	-0.0206	-0.6545	0.0050	-0.0086	0.1183	0.0196	<b>-0.1638</b>	0.0756	-0.0514
<b>X18</b>	0.0188	0.1209	-0.0881	0.0406	0.0044	-0.0018	0.0357	-0.0796	0.3409	0.0487	0.0465	-0.5380	0.0021	-0.0052	-0.0372	0.0099	-0.0651	<b>0.1903</b>	0.0438

**Residual value: 0.0825**

X1= Vine length, X2= Number of leaves per vine, X3= Number of branches per vine, X4= Number of nodes per vine, X5= Node at 1<sup>st</sup> male flowering, X6= Node at 1<sup>st</sup> female flowering, X7= Days to 1<sup>st</sup> male flowering, X8= Days to 1<sup>st</sup> female flowering, X9= Days to 50% flowering, X10= Number of male flowers, X11= Number of female flowers, X12= Sex ratio, X13= Days to 1<sup>st</sup> fruit harvest, X14= Number of fruits per vine, X15= Average fruit weight, X16= Fruit length, X17= Fruit diameter, X18= Flesh thickness, rG= Genotypic correlation coefficient of fruit yield per vine.

of female flowers per vine (0.0465), days to 50 per cent flowering (0.3409), number of male flowers per vine (0.0487), number of nodes per vine (0.0406), days to first male flowering (0.0357), number of leaves per vine (0.1209), vine length (0.0188), fruit length (0.0099), node at first male flower (0.0044) and days to first fruit harvest (0.0021). While, negative indirect effect was seen through sex ratio (-0.5380), number of branches (-0.0881) and days to first female flowering (-0.0796).

#### **4.4 Genetic diversity**

The genetic diversity helps in assessing the nature of diversity in order to identify genetically diverse genotypes for their uses in heterosis programmes. In present study, twenty cucumber genotypes along with check were evaluated for 19 characters and the data obtained was subjected to  $D^2$  statistics to assess the genetic divergence. Six clusters were constructed using Tocher's method (Fig. 5).

##### **4.4.1 Mahalanobis Generalized distance ( $D^2$ ) analysis**

$D^2$  analysis was carried out using 19 traits studied. A generalized distance ( $D^2$ ) was calculated for each pair of genotypes.

##### **4.4.2 Relative contribution of different characters towards divergence (Table 10).**

Differences in proportion of contribution of each character to total diversity was presented in Table 10. Flesh thickness contributed maximum (72.86%) to the total diversity followed by fruit diameter (17.14%), fruit length (7.62%), average fruit weight (1.43%), number of female flowers (0.48%) and number of leaves (0.48%). The remaining all other traits did not contributed to the total diversity (Fig. 4).

##### **4.4.3 Group constellation (Table 11)**

The distribution pattern of genotypes into various clusters is presented in Table 11. Twenty genotypes along with check were grouped into six clusters by treating estimated  $D^2$  values as the squares of generalized distances. Cluster II was the largest cluster comprising of eight genotypes, followed by cluster I, which is having seven genotypes. Cluster III consisted three genotypes, whereas, cluster IV, V and VI were solitary clusters with single genotype (Fig. 3).

**Table 10. Per cent contribution of different characters towards divergence in cucumber genotypes**

<b>Sl. No</b>	<b>Characters</b>	<b>Times ranked 1<sup>st</sup></b>	<b>Per cent Contribution</b>
1	Flesh thickness (cm)	153	72.86
2	Fruit diameter (cm)	36	17.14
3	Fruit length (cm)	16	7.62
4	Average fruit weight (g)	3	1.43
5	Number of female flowers	1	0.48
6	Number of leaves per vine	1	0.48
7	Vine length (cm)	-	0
8	Number of branches per vine	-	0
9	Number of nodes per vine	-	0
10	Node at first male flowering	-	0
11	Node at first female flowering	-	0
12	Days to first male flowering	-	0
13	Days to first female flowering	-	0
14	Days to 50% flowering	-	0
15	Number of male flowers	-	0
16	Sex ratio	-	0
17	Days to first fruit harvest	-	0
18	Number of fruits per vine	-	0
19	Fruit yield per vine (kg)	-	0

**Table 11. Clustering pattern of 21 cucumber genotypes**

<b>Cluster number</b>	<b>No. of genotypes</b>	<b>Genotype name</b>
Cluster I	7	KRCCH-CC-10, KRCCH-CC-18, Arabhavi local, KRCCH-CC-5, KRCCH-CC-2, KRCCH-CC- 19, KRCCH-CC-20.
Cluster II	8	KRCCH-CC-9, KRCCH-CC-11, KRCCH-CC-12, KRCCH-CC-14, KRCCH-CC- 7, KRCCH-CC-3, KRCCH-CC-1, KRCCH-CC-8.
Cluster III	3	KRCCH-CC-4, KRCCH-CC- 6, KRCCH-CC-16.
Cluster IV	1	KRCCH-CC-13
Cluster V	1	KRCCH-CC-17
Cluster VI	1	KRCCH-CC-15

#### 4.4.4 Intra and inter cluster distance (Table 12)

Average intra and inter cluster distance for 21 cucumber genotypes were presented in the Table 12. Cluster II, which contains eight genotypes exhibited maximum intra cluster distance ( $D^2 = 2242.20$ ) followed by Cluster III ( $D^2 = 2166.64$ ) and Cluster I ( $D^2 = 1854.13$ ). Cluster IV, V and VI exhibited zero distance as they possess single genotype (Fig.5).

Inter-cluster distances depict that cluster III and cluster IV had maximum divergence ( $D^2 = 32489.21$ ) among them, followed by cluster III and cluster II ( $D^2 = 24315.24$ ). The least inter-cluster distance was observed between cluster IV and cluster VI ( $D^2 = 3080.32$ ).

#### 4.4.5 Cluster mean analysis

The cluster means for 19 different traits and overall character wise score across the six clusters are presented in table 13 were compared and indicated the considerable differences between clusters for all the characters.

##### 4.4.5.1 Vine length (cm)

Maximum vine length was observed in cluster IV (168.50) followed by cluster II (160.76). Whereas, cluster V showed minimum vine length (125.75).

##### 4.4.5.2 Number of leaves per vine

Cluster VI recorded highest number of leaves per vine (79.00) followed by cluster II (77.56). Least was observed in cluster V (50.50).

##### 4.4.5.3 Number of branches per vine

Cluster V recorded maximum number of branches per vine (4.73) followed by cluster VI (4.43). Whereas, minimum was seen in cluster III (1.43).

##### 4.4.5.4 Number of nodes per vine

Minimum number of nodes per vine was recorded in cluster VI (10.25) followed by cluster IV (10.50). Whereas, maximum was observed in cluster III (13.75).

Table 12. Average intra and inter cluster distances for 21 cucumber genotypes.

Clusters	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI
Cluster I	<b>1854.13</b>	6238.10	8770.80	11648.81	3629.47	10634.65
Cluster II		<b>2242.20</b>	24315.24	3876.82	10340.96	8166.18
Cluster III			<b>2166.64</b>	32489.21	6415.99	23310.39
Cluster IV				<b>0.00</b>	12048.24	3080.32
Cluster V					<b>0.00</b>	6128.77
Cluster VI						<b>0.00</b>

- Diagonal values indicate intra cluster distance
- Above diagonal values indicate inter cluster distance.

#### **4.4.5.5 Node at first male flowering**

Highest cluster mean for node at first male flowering was observed in cluster IV (3.45) followed by cluster II (3.06). Lowest cluster mean was recorded in cluster V (1.40).

#### **4.4.5.6 Node at first female flowering**

Cluster III recorded highest cluster mean (5.42) followed by cluster I (5.22). Whereas, lowest cluster mean was observed in cluster VI (3.65).

#### **4.4.5.7 Days to first male flowering**

For days to first male flowering, cluster V recorded early male flowering (30.50). Whereas, cluster III recorded late male flowering (39.83).

#### **4.4.5.8 Days to first female flowering**

Cluster II recorded early female flowering (41.14) followed by cluster V (42.25). Whereas, late female flowering was observed in cluster III (44.95).

#### **4.4.5.9 Days to 50 per cent flowering**

For days to 50 per cent flowering, cluster VI showed lowest cluster mean (49.00). While, cluster V recorded highest cluster mean (58.63).

#### **4.4.5.10 Number of male flowers per vine**

Maximum number of male flowers was observed in cluster II (77.59) followed by cluster III (72.30). While, cluster IV showed minimum number of male flowers (58.85).

#### **4.4.5.11 Number of female flowers per vine**

Cluster V recorded maximum number of female flowers (12.50) followed by cluster VI (9.80). Whereas, minimum was observed in cluster II (7.50).

#### **4.4.5.12 Sex ratio**

Cluster II recorded maximum sex ratio (11.34) followed by cluster III (8.50). Whereas, minimum was observed in cluster V (4.90).

#### **4.4.5.13 Days to first fruit harvest**

Minimum days to first fruit harvest was observed in cluster V (48.00) followed by cluster VI (51.75). Whereas, cluster IV (60.00) showed maximum days to first fruit harvest.

#### **4.4.5.14 Number of fruits per vine**

Cluster V recorded highest number of fruits per vine (9.63) followed by cluster IV (8.38) and it was lowest in cluster II (4.13).

#### **4.4.5.15 Fruit yield per vine (kg)**

Highest fruit yield per vine was observed in cluster VI (2.50) followed by cluster III (2.10). Whereas, cluster I showed lowest fruit yield per vine (1.10).

#### **4.4.5.16 Average fruit weight (g)**

The average fruit weight was highest in cluster VI (276.05) followed by cluster IV (265.75) and it was lowest in cluster I (173.77).

#### **4.4.5.17 Fruit length (cm)**

For fruit length, cluster V showed maximum fruit length (26.20). Whereas, cluster I recorded minimum (12.34).

#### **4.4.5.18 Fruit diameter (cm)**

Maximum fruit diameter was observed in cluster V (7.75) followed by cluster II (6.49). The minimum fruit diameter was observed in cluster I (5.48).

#### **4.4.5.19 Flesh thickness (cm)**

Cluster V recorded maximum flesh thickness (2.30) followed by cluster IV (2.20) and minimum was observed in cluster III (1.78).

**Table 13. Cluster means for 19 traits from D<sup>2</sup> analysis and their rankings**

Sl. No	Character	Ranking	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI
1	Vine length (cm)		146.79	160.76	146.02	168.50	125.75	154.40
		R	4	2	5	1	6	3
2	Number of leaves per vine		55.93	77.56	63.17	58.00	50.50	79.00
		R	5	2	3	4	6	1
3	Number of branches per vine		2.34	3.01	1.43	3.30	4.73	4.43
		R	5	4	6	3	1	2
4	Number of nodes per vine		12.78	11.56	13.75	10.50	11.00	10.25
		R	2	3	1	5	4	6
5	Node at first male flowering		2.85	3.06	1.72	3.45	1.40	1.50
		R	4	5	3	6	1	2
6	Node at first female flowering		5.22	4.90	5.42	5.00	4.75	3.65
		R	5	3	6	4	2	1
7	Days to first male flowering		37.32	34.69	39.83	39.25	30.50	38.25
		R	3	2	6	5	1	4
8	Days to first female flowering		43.21	41.14	44.95	42.75	42.25	44.25
		R	4	1	6	3	2	5
9	Days to 50 per cent flowering		53.48	51.94	56.04	52.50	58.63	49.00
		R	4	2	5	3	6	1
10	Number of male flowers		65.89	77.59	72.30	58.85	59.90	65.85
		R	3	1	2	6	5	4
11	Number of female flowers		8.22	7.50	9.77	7.65	12.50	9.80
		R	4	6	3	5	1	2
12	Sex ratio		8.31	11.34	8.50	7.80	4.90	6.85
		R	3	1	2	4	6	5
13	Days to first fruit harvest		53.34	53.32	53.92	60.00	48.00	51.75
		R	4	3	5	6	1	2

Sl. No	Character	Ranking	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI
14	Number of fruits per vine		5.46	4.13	5.67	6.63	9.63	8.38
		R	5	6	4	3	1	2
15	Fruit yield per vine (kg)		1.10	1.11	1.33	2.10	1.28	2.50
		R	6	5	3	2	4	1
16	Average fruit weight (g)		173.77	189.29	229.45	265.75	225.05	276.05
		R	6	5	3	2	4	1
17	Fruit length (cm)		12.34	19.53	18.52	21.65	26.20	23.45
		R	6	5	4	3	1	2
18	Fruit diameter (cm)		5.48	6.49	5.62	5.35	7.75	4.50
		R	4	2	3	5	1	6
19	Flesh thickness (cm)		2.01	2.09	1.78	2.20	2.30	1.90
		R	4	3	6	2	1	5
		Overall score	88	61	76	72	54	55
		R	6	3	5	4	1	2

## 4.5 Pest and disease incidence

Response of cucumber genotypes for the incidence of fruit fly and powdery mildew are presented in the Table 14.

### 4.5.1 Fruit fly incidence (%)

Among 21 genotypes evaluated, ten genotypes were highly resistant (KRCCH-CC-3, KRCCH-CC-4, KRCCH-CC-5, KRCCH-CC-7, KRCCH-CC-9, KRCCH-CC-11, KRCCH-CC-12, KRCCH-CC-13, KRCCH-CC-14 and KRCCH-CC-18). Genotypes KRCCH-CC-17 and Arabhavi local were resistant. Moderate resistance was observed in seven genotypes *viz.*, KRCCH-CC-2, KRCCH-CC-6, KRCCH-CC-8, KRCCH-CC-10, KRCCH-CC-15, KRCCH-CC-19 and KRCCH-CC-20. While the genotypes KRCCH-CC-1 and KRCCH-CC-16 were moderately susceptible (Table 15).

Based on the response of genotypes to fruit fly incidence (%), they are grouped into different categories (Table 15).

### 4.5.2 Powdery mildew disease severity (%)

Five genotypes *viz.*, KRCCH-CC-1, KRCCH-CC-2, KRCCH-CC-4, KRCCH-CC-10 and KRCCH-CC-18 showed complete absence of powdery mildew. Whereas, two genotypes *viz.*, KRCCH-CC-3 and KRCCH-CC-6 showed resistance. Moderate resistance was observed in genotypes KRCCH-CC-8, KRCCH-CC-9, KRCCH-CC-11, KRCCH-CC-12, KRCCH-CC-13, KRCCH-CC-14, KRCCH-CC-15, KRCCH-CC-16, KRCCH-CC-19 and Arabhavi local. Genotypes like KRCCH-CC-5, KRCCH-CC-7, KRCCH-CC-17 and KRCCH-CC-20 showed moderate susceptibility to powdery mildew (Table 14).

Based on the reaction of genotypes to powdery mildew incidence (%), they are grouped into different categories (Table 16).

## 4.6 Identification of superior cucumber genotypes for productivity related traits (Table 15)

As per the results obtained from various statistical analysis, we could identify the best genotypes considering the economically important traits of cucumber like total

**Table 14. Response of cucumber genotypes for pest and disease incidence**

<b>Sl. No</b>	<b>Genotypes</b>	<b>Fruit fly incidence (%)</b>	<b>Score</b>	<b>Powdery mildew incidence (%)</b>	<b>Score</b>
1	KRCCH-CC-1	34.5	3	0.00	0
2	KRCCH-CC-2	21.5	2	0.00	0
3	KRCCH-CC-3	0	0	11.63	1
4	KRCCH-CC-4	0	0	0.00	0
5	KRCCH-CC-5	0	0	27.76	3
6	KRCCH-CC-6	24.5	2	7.62	1
7	KRCCH-CC-7	0	0	38.18	3
8	KRCCH-CC-8	23	2	12.53	2
9	KRCCH-CC-9	0	0	19.72	2
10	KRCCH-CC-10	17	2	0.00	0
11	KRCCH-CC-11	0	0	24.67	2
12	KRCCH-CC-12	0	0	15.12	2
13	KRCCH-CC-13	0	0	12.87	2
14	KRCCH-CC-14	0	0	11.38	2
15	KRCCH-CC-15	13.12	2	23.28	2
16	KRCCH-CC-16	29.5	3	18.36	2
17	KRCCH-CC-17	10.5	1	36.61	3
18	KRCCH-CC-18	0	0	0.00	0
19	KRCCH-CC-19	18.39	2	21.34	2
20	KRCCH-CC-20	19.19	2	29.70	3
21	Arabhavi local	0	0	18.42	2

**Table 15: Grouping of cucumber genotypes based on response to fruit fly infestation**

Sl. No	Reaction category	Number of genotypes	Genotypes
1	Highly resistant	10	KRCCH-CC-3, KRCCH-CC-4, KRCCH-CC-5, KRCCH-CC-7, KRCCH-CC-9, KRCCH-CC-11, KRCCH-CC-12, KRCCH-CC-13, KRCCH-CC-14 and KRCCH-CC-18
2	Resistant	2	KRCCH-CC-17 and Arabhavi local
3	Moderate resistance	7	KRCCH-CC-2, KRCCH-CC-6, KRCCH-CC-8, KRCCH-CC-10, KRCCH-CC-15, KRCCH-CC-19 and KRCCH-CC-20
4	Moderate susceptible	2	KRCCH-CC-1 and KRCCH-CC-16

**Table 16: Grouping of cucumber genotypes based on response to powdery mildew incidence**

Sl. No	Reaction category	Number of genotypes	Genotypes
1	Highly resistant	5	KRCCH-CC-1, KRCCH-CC-2, KRCCH-CC-4, KRCCH-CC-10 and KRCCH-CC-18
2	Resistant	2	KRCCH-CC-3 and KRCCH-CC-6
3	Moderate resistance	10	KRCCH-CC-8, KRCCH-CC-9, KRCCH-CC-11, KRCCH-CC-12, KRCCH-CC-13, KRCCH-CC-14, KRCCH-CC-15, KRCCH-CC-16, KRCCH-CC-19 and Arabhavi local.
4	Moderate susceptible	4	KRCCH-CC-5, KRCCH-CC-7, KRCCH-CC-17 and KRCCH-CC-20

number of fruits per vine, average fruit weight, fruit yield per vine, fruit length, flesh thickness and resistance to pest and diseases. The mean performances of various genotypes for all the 24 traits are listed in Appendix II.

For total number of fruits per vine, genotypes like KRCCH-CC-17, KRCCH-CC-16, KRCCH-CC-15, KRCCH-CC-5 and KRCCH-CC-13 showed best performance among all the 21 genotypes under the study with the total number of fruits of 9.62, 9.37, 8.37, 6.62 and 6.62 respectively.

For average fruit weight, genotypes like KRCCH-CC-6, KRCCH-CC-15, KRCCH-CC-13, KRCCH-CC-8 and KRCCH-CC-7 showed good performance among all the 21 cucumber genotypes under the study with the average fruit weight of 349.00 g, 276.05 g, 265.75 g, 263.25 g and 257.95 g respectively.

For fruit yield per vine, genotypes like KRCCH-CC-15, KRCCH-CC-13, KRCCH-CC-8, KRCCH-CC-3 and KRCCH-CC-18 showed higher yield compared to other cucumber genotypes under the study with fruit yield of 2.5 kg, 2.10 kg, 1.80 kg, 1.60 kg and 1.55 kg.

The maximum fruit length was observed in genotypes, KRCCH-CC-17 (26.20 cm), KRCCH-CC-7 (23.60), KRCCH-CC-15 (23.45 cm), KRCCH-CC-2 (22.50 cm) and KRCCH-CC-14 (22.05 cm) compared to other cucumber genotypes under the study.

The maximum flesh thickness was recorded in KRCCH-CC-1 (2.80 cm), KRCCH-CC-2 (2.45 cm), KRCCH-CC-20 (2.32 cm), KRCCH-CC-17 (2.30 cm) and KRCCH-CC-12 (2.25 cm) compared to other cucumber genotypes under the study.

Genotypes like KRCCH-CC-4, KRCCH-CC-18 and KRCCH-CC-3 showed resistance to both powdery mildew incidence and fruit fly infestation

**Table 17: Identification of superior cucumber genotypes based on productivity trait**

<b>Sl. No</b>	<b>Character</b>	<b>Genotypes</b>
1	Total number of fruits per vine	KRCCH-CC-17, KRCCH-CC- 16, KRCCH-CC-15, KRCCH-CC-5 and KRCCH-CC-13.
2	Average fruit weight (g)	KRCCH-CC-6, KRCCH-CC-15, KRCCH-CC-13, KRCCH-CC-8 and KRCCH-CC-7.
3	Fruit yield per vine (kg)	KRCCH-CC-15, KRCCH-CC-13, KRCCH-CC-8, KRCCH-CC-3 and KRCCH-CC-18
4	Fruit length (cm)	KRCCH-CC-17, KRCCH-CC- 7, KRCCH-CC- 15, KRCCH-CC-2 and KRCCH-CC-14
5	Flesh thickness (cm)	KRCCH-CC-1, KRCCH-CC-2, KRCCH-CC- 20, KRCCH-CC-17 and KRCCH-CC-12
6	Resistance to pest and diseases. (Both fruit fly and powdery mildew)	KRCCH-CC-4, KRCCH-CC-18 and KRCCH-CC-3



**KRCCH-CC-18**



**KRCCH-CC-13**



**KRCCH-CC-8**



**KRCCH-CC-3**



**KRCCH-CC-15**

**Plate 2: Top five high yielding Cucumber genotypes**

## 5. DISCUSSION

Cucumber is one of the important vegetable grown in tropical and subtropical parts of India. It is known for its high nutritional values. However, the potential of commercially grown cultivars is highly affected by variable environments. In addition to the genetical behavior of different desirable genotypes, they also vary due to outcrossing/open or natural pollination.

The prime objective of plant breeding programme is to develop high yielding varieties with good quality traits. Yield is a complex character and is a combined result of a number of component traits. Yield is generally controlled by polygene and influenced greatly by the environmental fluctuations. For identification of strains for important characters, assessment of genetic variability in available germplasm is prerequisite tool in commercially successful breeding programmes.

The success of a crop improvement programme depends on the extent of genetic variability existing in the population or germplasm. The magnitude of genetic variability can determine the pace and quantum of genetic improvement through selection or hybridization followed by selection. Phenotypic variance measures the magnitude of variation arising out of differences in phenotypic values, while the genotypic variance measures the magnitude of variation due to difference in genotypic values.

Heritability value itself does not provide any indication of the amount of best individual. Ramanujam and Tirumalachar (1967) reported that heritability estimates in broad sense accompanied with genetic advance would be more reliable in nature. Grafius (1959) pointed out that the structure of yield proved through its components rather than directly would be more efficient. The study of yield components and their inter-relationship along with yield and their direct and indirect contribution to yield is of immense importance. Path analysis by Dewey and Lu (1959) gives cause and effect relationship critically breaking up different direct and indirect effects, which finally make up correlation coefficient.

In the present investigation, an attempt was made to study the estimation of proportion of variability, broad sense heritability, predicted genetic advance, GCV and PCV with respect to 24 traits. The association among these characters and their direct and

indirect effect on fruit yield has also been studied. The results presented in previous chapter are discussed under following headings:

- 5.1 Genetic variability, heritability and genetic advance
- 5.2 Correlation studies
- 5.3 Path analysis
- 5.4 Genetic diversity

## **5.1 Genetic variability, heritability and genetic advance**

### **5.1.1 Plant growth parameters**

In the present investigation, high GCV and PCV were observed for number of leaves per vine and number of branches per vine. These results are in agreement with Hanchinmani *et al.* (2011), Afangideh *et al.* (2007), Chikezie *et.al* (2016) and Monisha *et al.* (2017). However, vine length and number of nodes per vine showed moderate GCV and high PCV values, which is in agreement with Veena *et al.* (2012), Yadav *et al.* (2012), Kandaswamy, R. (2017) and Monisha *et al.* (2017). Narrow difference between GCV and PCV indicated little environment effect and may be governed by non-additive genes. (Fig. 1)

High heritability and GAM was seen for vine length, number of leaves per vine and number of branches per vine (Fig. 2) which are in line with the results of Ud-Din *et al.* (2006), Hanchinmani *et al.* (2011), Yadav *et al.* (2012), Kandaswamy. R. (2017), Monisha *et al.* (2017) and Chandan Singh *et al.*(2018). High GAM and moderate heritability was observed for number of nodes per vine. High heritability with high GAM estimates for these traits indicated the role of additive gene action in governing their expression. Hence, selection on phenotype would be beneficial in improvement of these traits.

### **5.1.2 Flowering and earliness characters**

High GCV, PCV, heritability and GAM were observed for node at first male flower, node at first female flower, number of male flowers, number of female flowers,

sex ratio and fruit diameter. These results are in line with Ud-Din *et al.* (2006), Chikezie *et al.* (2016), Kandaswamy (2017) and Chandan Singh *et al.* (2018). This suggested that selection may be rewarding for these characters as additive gene action is predominantly responsible for the expression of the traits.

Moderate PCV, heritability and GAM along with low GCV was observed for days to first male flowering, days to first female flowering and days to 50 per cent flowering which are in agreement with Rajwat *et al.* (2017). While, days to first fruit harvesting showed low GCV, PCV and GAM with moderate heritability, which is in line with Monisha *et al.* (2017). Whereas, high heritability and GAM was observed for fruit diameter which was similar with the results of Ud-Din *et al.* (2006), Arunkumr *et al.* (2011), Hanchinmani *et al.* (2011), Yadav *et al.* (2012) and Kandaswamy (2017). Hence, these traits may be improved through selection.

### **5.1.3 Quality parameters**

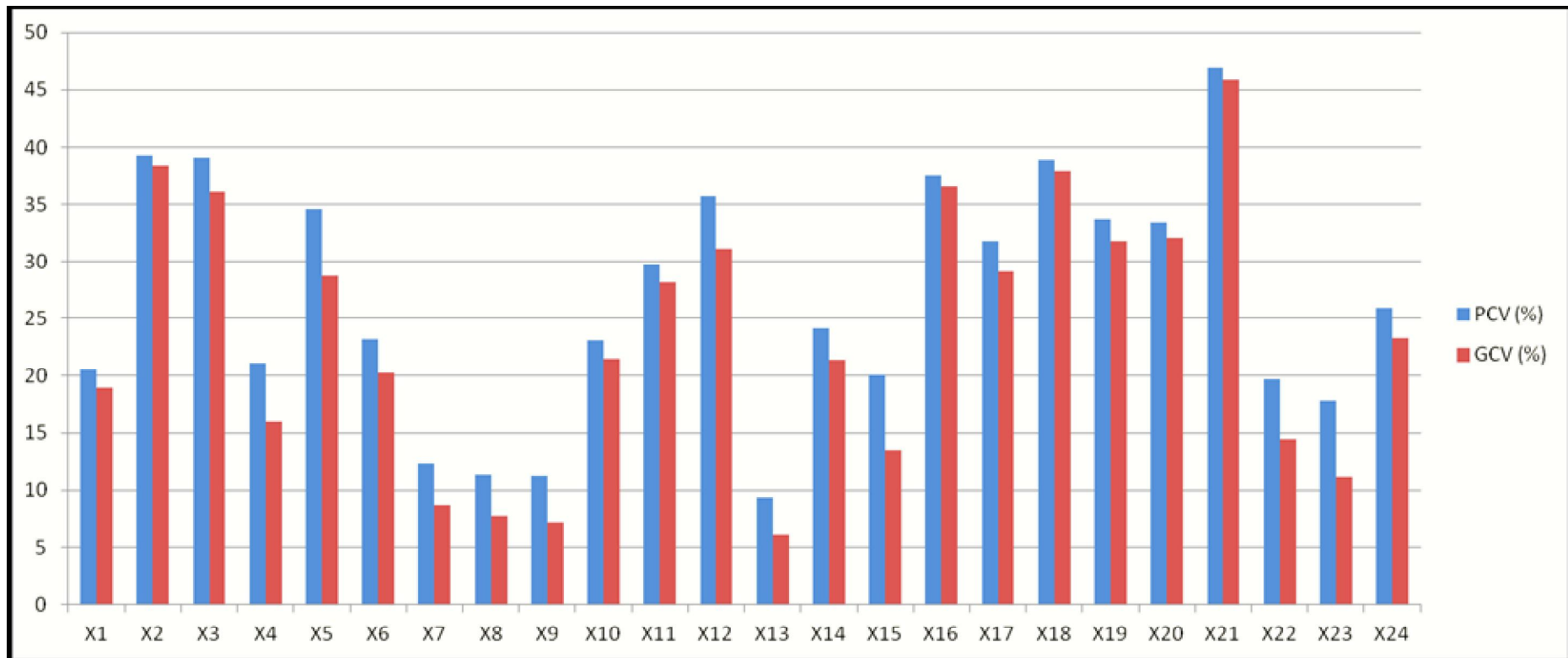
Flesh thickness showed high PCV and moderate GCV, heritability and GAM. This finding is similar with Basavarajeshwari *et al.* (2014). This suggested that selection of these traits may be rewarding as additive gene action is predominantly responsible for the expression of the traits.

### **5.1.4 Yield parameters**

High GCV, PCV, heritability and GAM was observed for total number of fruits per vine, average fruit weight, yield per vine and fruit length. These results are in agreement with Ud-Din *et al.* (2006), Hanchinmani *et al.* (2011), Kumar *et al.* (2013), Basavarajeshwari *et al.* (2014), Kandaswamy (2017) and Monisha *et al.* (2017). This indicated the presence of additive gene effect for these traits, thus simple selection will be helpful. However, yield is a complex character, which cannot lead success in direct selection based on it. So, characters associated and contributable for this character must be studied after which selection will be promising.

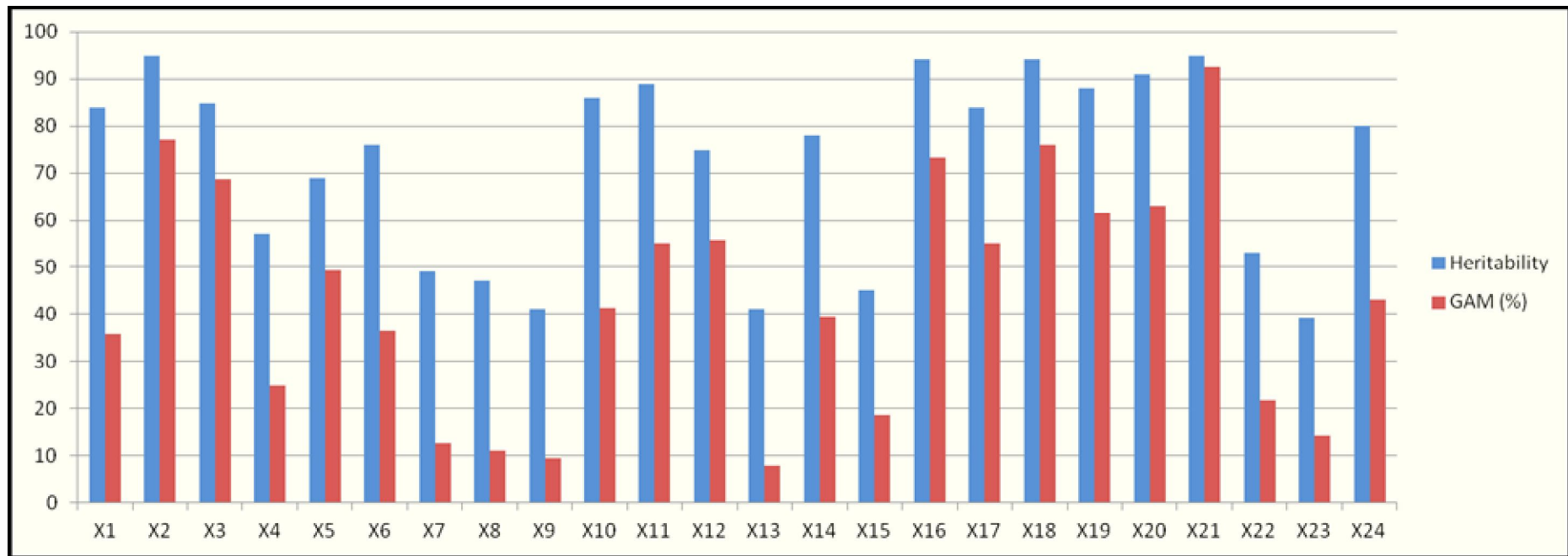
### **5.1.5 Seed parameters**

Number of seeds per fruit and seed yield per fruit recorded high GCV, PCV, heritability and GAM, which are in line with the findings of Basavarajeshwari *et al.*



**Fig 1: Phenotypic coefficient of variation and genotypic coefficient of variation for different characters in cucumber genotypes**

X1=Vine length	X6 = Node at first female flower	X11= Number of female flowers	X16= Number of fruits per vine	X21=Seed yield per fruit
X2=Number of leaves per vine	X7= Days to first male flowering	X12= Sex ratio	X17=Average fruit weight	X22=Seed length
X3=Number of branches per vine	X8= Days to first female flowering	X13= Days to 1 <sup>st</sup> fruit harvest	X18=Fruit yield per vine	X23=Seed width
X4=Number of nodes per vine	X9= Days to 50% flowering	X14=Fruit diameter	X19=Fruit length	X24=Test weight
X5= Node at first male flower	X10= Number of male flowers	X15= Flesh thickness	X20=Number of seeds per fruit	



**Fig. 2: Heritability and genetic advance over mean for different characters in cucumber genotypes**

X1=Vine length

X2=Number of leaves per vine

X3=Number of branches per vine

X4=Number of nodes per vine

X5= Node at first male flower

X6 = Node at first female flower

X7= Days to first male flowering

X8= Days to first female flowering

X9= Days to 50% flowering

X10= Number of male flowers

X11= Number of female flowers

X12= Sex ratio

X13= Days to 1<sup>st</sup> fruit harvest

X14= Fruit diameter

X15= Flesh thickness

X16= Number of fruits per vine

X17=Average fruit weight

X18=Fruit yield per vine

X19=Fruit length

X20=Number of seeds per fruit

X21=Seed yield per fruit

X22=Seed length

X23=Seed width

X24=Test weight

(2014). Whereas, seed length and seed width showed moderate GCV, PCV and heritability, which are similar to the research findings of Kandaswamy (2017) and Chandan Singh *et al.* (2018). Seed length and seed width showed high and low GAM respectively. Hence, these traits may be improved through selection.

## 5.2 Correlation studies

The interrelationship between two characters can be directly observed by the phenotypic correlations. The genotypic correlation may be interpreted as the correlation of breeding value. When two characters are invariably and linearly associated, the genetic mechanism causing such association may be due to complete linkage between the two traits or pleiotropy and some gene may increase both the traits (positive association), while other may increase one and reduce the other (negative association). Hence, correlation study has greater significance and could be effectively utilized in formulating an effective selection scheme.

In the present investigation, genotypic and phenotypic correlation coefficients were worked out for growth and yield components and heritability of both genotypic and phenotypic association has been discussed. A narrow difference between the estimates of phenotypic and genotypic correlation was observed (Table 4 and 5) for various traits and this indicates the lesser influence of environment in the expression of these traits and presence of strong inherent association among the traits.

Vine length had positive and significant association with number of male flowers per vine and fruit diameter. These findings are in agreement with Afangideh and Uyoh (2007) and Hossain *et al.* (2010). The other growth parameters like number of leaves per vine with number of male flowers per vine, number of nodes per vine with number of female flowers per vine showed positive and significant association among each other.

From the study conducted, among all the characters, fruit yield per vine was found to be positively and significantly associated with number of female flowers per vine, vine length, number of leaves per vine and average fruit weight at both phenotypic and genotypic level. These results are in conformity with Saikia *et al.* (1995), Singh (1997), Tripathi (1997), Meng *et al.* (1999), Ram *et al.* (2001), Singh *et al.* (2002),

Verma (2003), Rao *et al.* (2004), Ying *et al.* (2004), Mohd and Khan (2009), Kumar *et al.* (2008), Hanchinamani and Patil (2011) and Saheb *et al.* (2017). Therefore, applying selection pressure on traits like number of female flowers per vine, number of fruits per vine and fruit weight would simultaneously result in selection for higher fruit yield per vine.

### 5.3 Path coefficient analysis

The correlation coefficient measures the relationship existing between pairs of characters. But, dependent character is an interaction product of many mutually associated component characters and change in any one component will disturb whole network of cause and affect system. The path coefficient analysis, a statistical device developed by Wright (1921), which takes into account the cause and effect and relation between the variables, is a unique in partitioning the association into direct and indirect effects through other independent variables. Path analysis also measures the relative importance of causal factors involved. This is simply a standardizes partial regression analysis, wherein total correlation value is subdivided into casual scheme.

Among all the characters studied, average fruit weight, vine length, number of female flowers per vine, number of fruits per vine, number of leaves per vine, number of branches per vine, fruit length and flesh thickness had positive direct effect on fruit yield per vine. These findings are in agreement with Meng *et al.* (1999), Rao *et al.* (2004), Kumar *et al.* (2008), Hanchinamani and Patil (2008), Hossain *et al.* (2010), Singh *et al.* (2009), Kumar *et al.* (2011), Veena *et al.* (2013) and Hasan *et al.* (2015).

From the present path analysis study in cucumber, it may be revealed that improvement in fruit yield per vine can be achieved by carrying selection for component characters like average fruit weight, vine length, number of female flowers per vine, number of fruits per vine, number of leaves per vine, number of branches per vine, fruit length and flesh thickness, which had positive direct effect on fruit yield per vine.

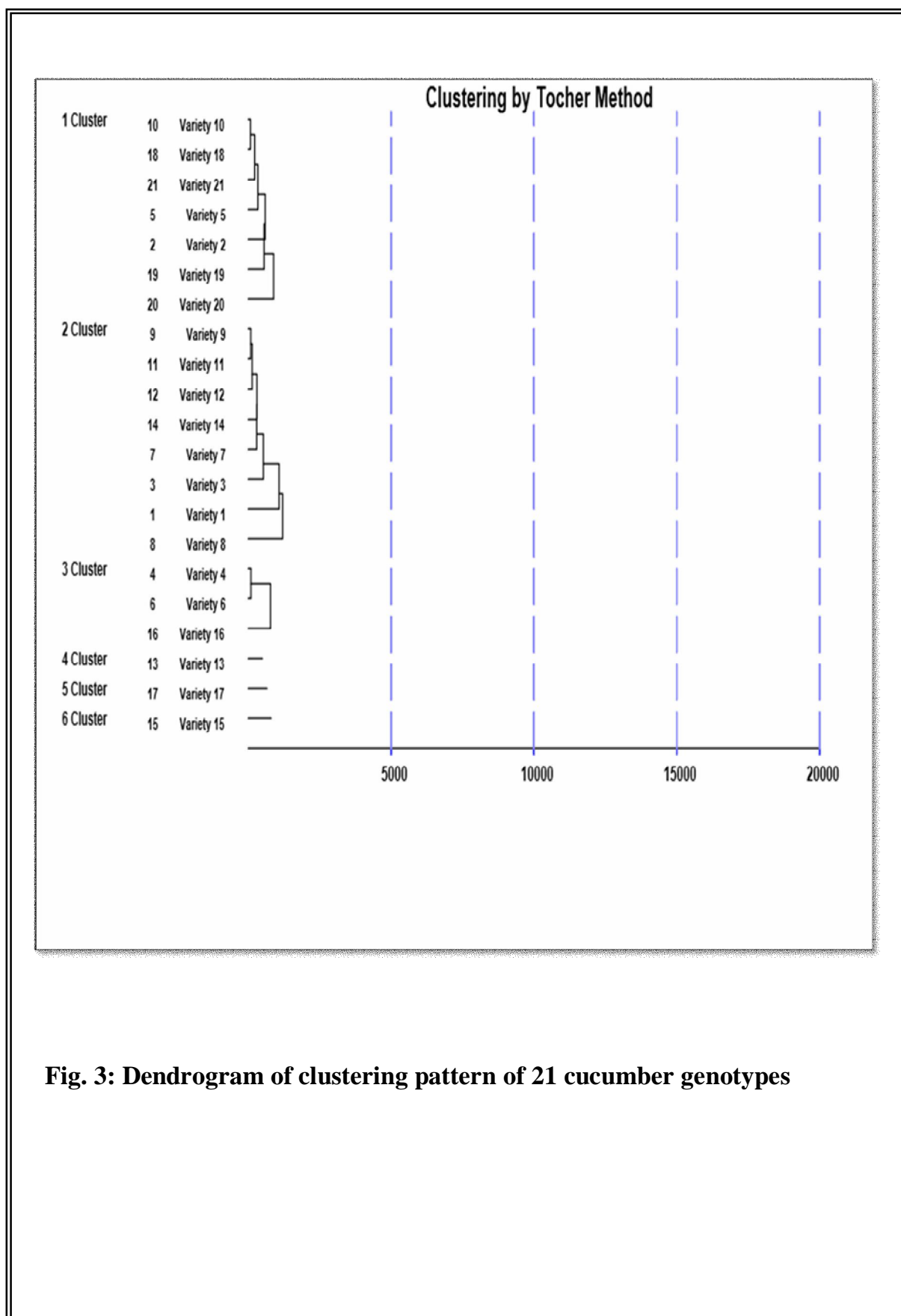
## 5.4 Genetic Diversity

The importance of genetic diversity has been widely appreciated. Recognising and estimating such diversity has always been a difficult task. Multivariate analysis utilizing the concept of statistical distance has been found to be very powerful statistical tool in estimating diversity in biological populations. It has been successfully employed even in situations, where overlapping of characters rendered the conventional methods of classification is ineffective (Sakal, 1965; Murthy *et al.*, 1967). Ecological diversity has been regarded as a reasonable index of diversity (Vavilov, 1926 and Moll *et al.*, 1962). Assuming this, the cultivar from widely separated localities have been included in the hybridization programme by most of the plant breeders for recovering promising segregants. On contrary, Sachan and Sharma (1971), Kumar *et al.*, (2000) and Rameshbabu and Patil (2002) could not find any relation between geographical distribution and genetic diversity in crop plants belonging to different breeding system.

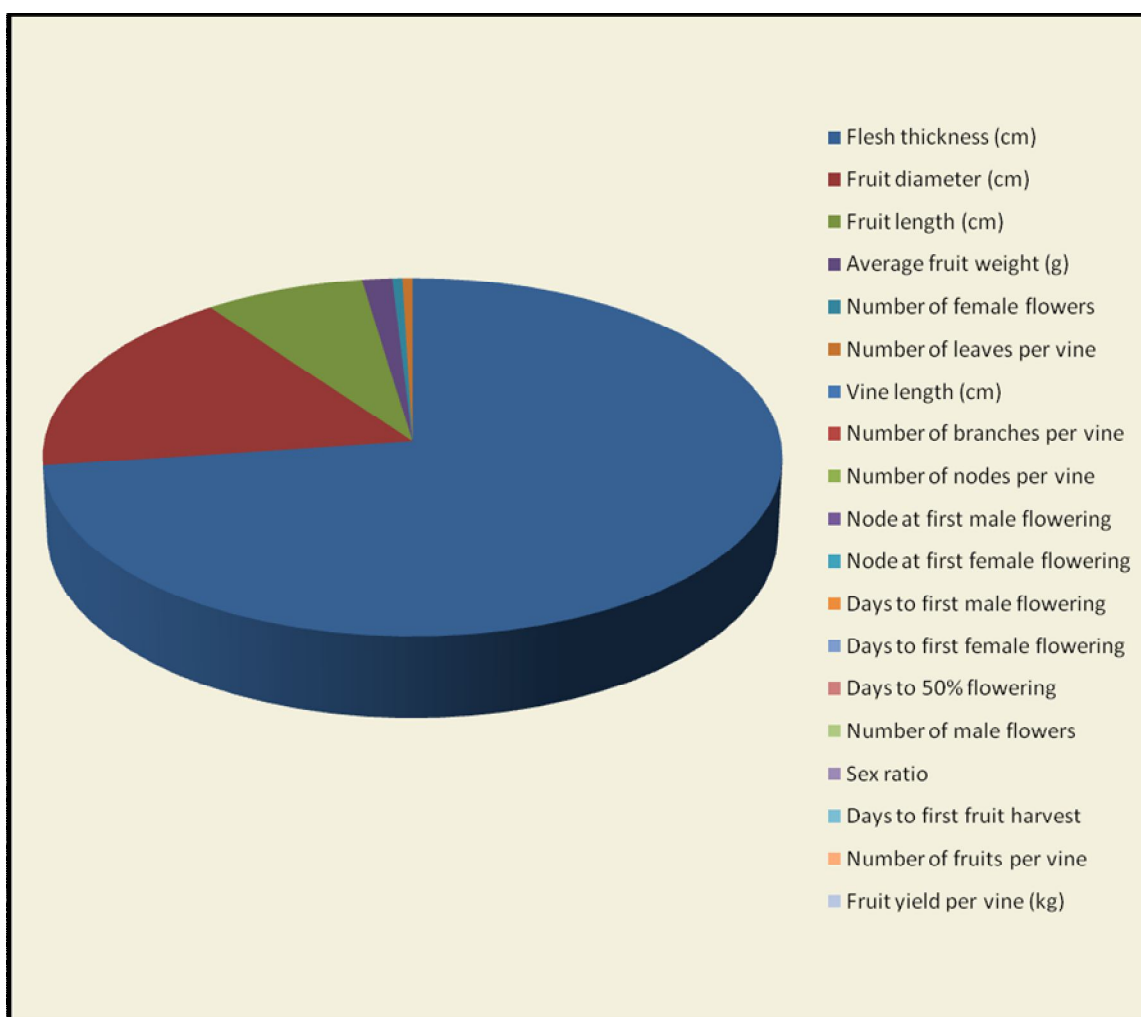
The 20 cucumber genotypes along with a check included in the present study had considerable diversity as observed by the magnitude of all possible  $D^2$  values, which ranged from 3080.32 to 32489.21. These 21 genotypes were grouped into six clusters based on  $D^2$  values.

Intra-cluster distance revealed that, cluster II consisting of eight genotypes had maximum intra-cluster diversity ( $D^2 = 2242.20$ ) indicating that the genotypes belonging to cluster II are closely related followed by cluster III ( $D^2 = 2166.64$ ) and cluster I ( $D^2 = 1854.13$ ). Cluster IV, V and VI had no intra-cluster distance ( $D^2 = 0.00$ ) as they possess single genotype. However, present investigation revealed that there was a considerable high intra-cluster distance among the genotypes in cluster I, II and III indicting the presence of sufficient amount of diversity with genotypes of respective clusters. Thus, there is a scope for selection among the genotypes within the clusters.

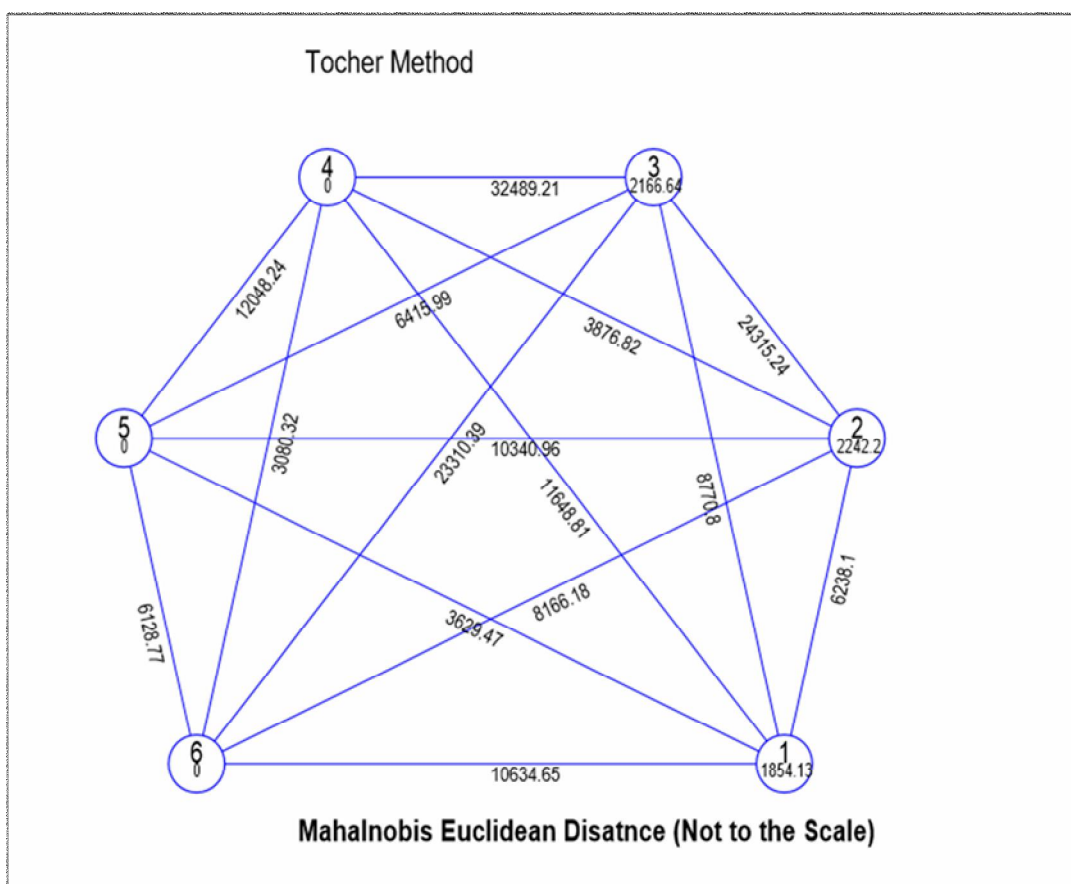
Based on distance between clusters *i.e.*, inter-cluster distance, maximum divergence was observed between cluster IV and cluster III ( $D^2 = 32489.21$ ) followed by cluster III and cluster II ( $D^2 = 24315.24$ ). The least inter-cluster distance was observed between cluster IV and cluster VI ( $D^2 = 3080.32$ ). Therefore, to obtain higher heterosis, select the superior genotypes from the clusters IV and III for hybridization.



**Fig. 3: Dendrogram of clustering pattern of 21 cucumber genotypes**



**Fig. 4: Per cent contribution of different traits towards divergence in cucumber genotypes**



**Fig. 5: Inter and intra cluster distance between 21 cucumber genotypes**

#### 5.4.1 Per cent contribution to diversity

Among all the 19 traits studied, six traits *viz.* flesh thickness contributed maximum to genetic diversity followed by fruit diameter, fruit length, average fruit weight, number of female flowers and number of leaves. These findings are in line with Sharma and Sharma (2006), Faruk *et al.* (2010), Gaikwad *et.al* (2011b), Kumar *et al.* (2013) and Rai *et al.* (2018). Hence, apart from selecting genotypes from clusters, which have higher inter cluster distance for hybridization, one can also think of selecting parents based on extent of genetic divergence in respect to a particular trait of interest.

#### 5.4.2 Analysis of cluster means

All genotypes spread over six clusters and means were scored across the clusters for all the 19 characters. The highest cluster mean was given the first rank and next clusters possessing next best means were given second, third, and so on up to sixth rank for all the traits except node at first male flower, node at first female flower, days to first male flowering, days to first female flowering, days to 50 per cent flowering and days to first fruit harvest, where lowest values were given first rank and highest values was last rank. Accordingly, cluster V with overall score of 54 across 19 characters secured first rank followed by clusters VI, II, IV, III and I indicating presence of most promising genotypes in them and can be extensively used for further breeding programme to generate new material.

### 5.5 Pest and disease incidence

#### 5.5.1 Fruit fly infestation

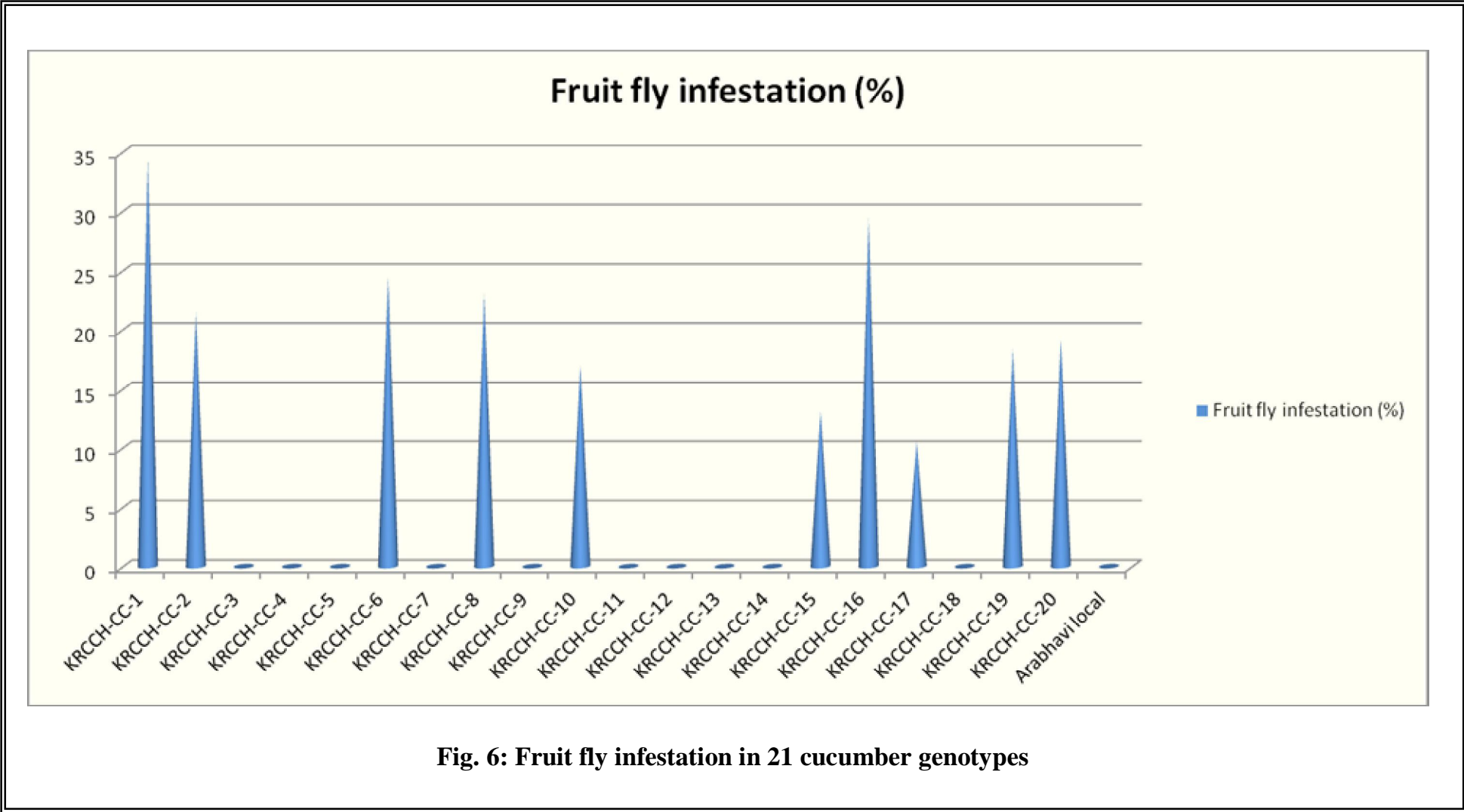
Among 21 genotypes evaluated, ten genotypes were highly resistant to fruit fly and one genotype was resistant. Moderate resistance was seen in seven genotypes. While, two genotypes, KRCCH-CC-1 and KRCCH-CC-16 were moderately susceptible (Fig. 6). Though most of the genotypes showed resistant to pest reaction, few among them showed infestation but were negligible. So, utilization of these genotypes for future breeding programme will be helpful.

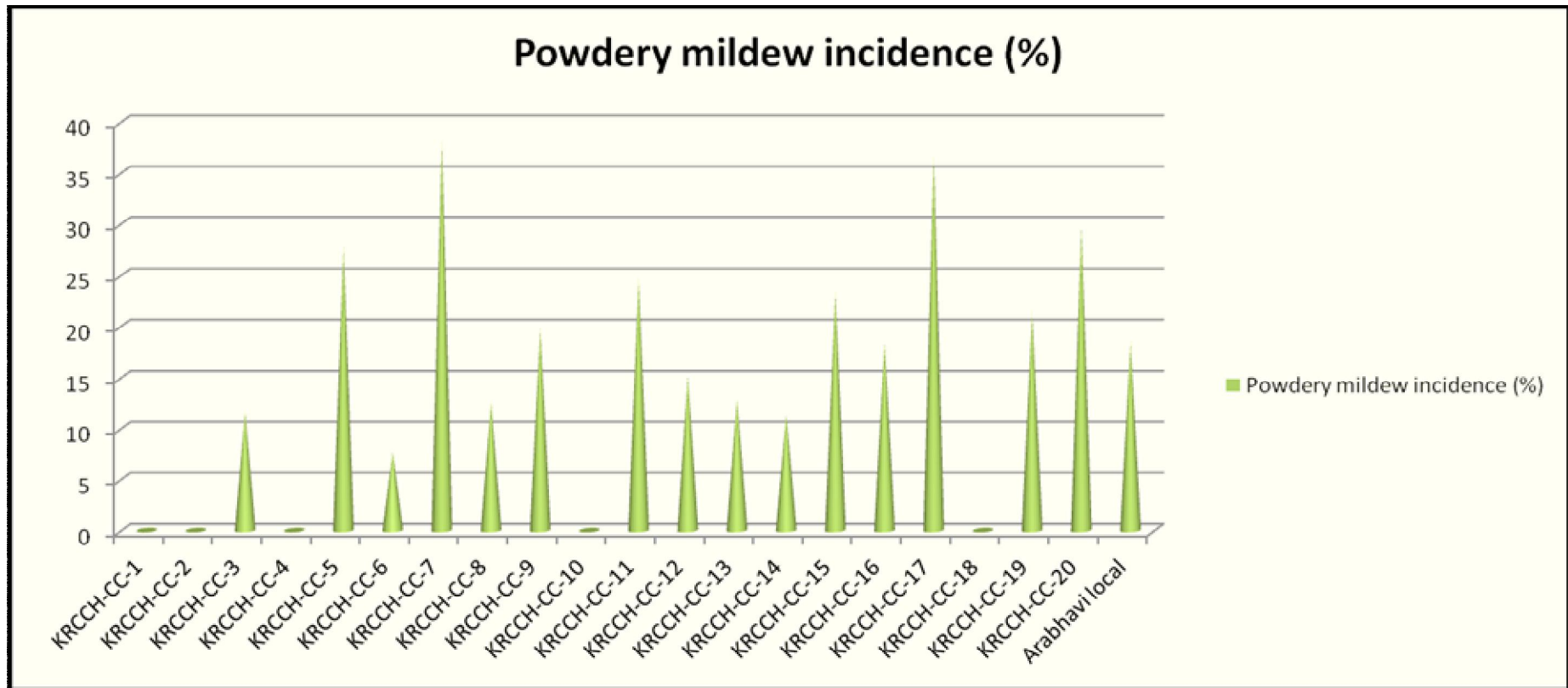
### 5.5.2 Powdery mildew incidence

Powdery mildew resistance in cucumber is governed by two major genes and polygenes in which susceptibility is incompletely dominant. Both the major genes are highly heritable in nature (Su-xin *et al.*, 2007). Complete absence of powdery mildew was seen in five genotypes included in the study (Fig. 7). Whereas, two genotypes were found to be resistant. However, the collection also included nine moderately susceptible ones, which showed disease incidence. As the present investigation includes several highly resistant and resistant genotypes, these are advisable for further crop improvement programme.

### Future line of work

- The genetic diversity study revealed that, diversity is largely contributed by flesh thickness, fruit diameter, fruit length, average fruit weight, number of female flowers and number of leaves. Hence, due weightage should be given for these characters in future to improve yield through selection.
- The lines identified for higher fruit yield *viz.*, KRCCH-CC-15, KRCCH-CC-13, KRCCH-CC-8, KRCCH-CC-3 and KRCCH-CC-18 may directly released as variety after thorough evaluation. High yielding advanced genotypes may be used in hybridization programme.
- Cluster VI and IV exhibited high cluster mean for yield character. Hence, these can be extensively used for future breeding programme to generate new material.
- Cluster IV and cluster III exhibited highest inter cluster distance. Selection of genotypes from these clusters for heterosis breeding will be rewarding.
- The present investigation revealed that, the characters like number of female flowers per vine, vine length, number of leaves per vine and average fruit weight were positively and significantly correlated. Whereas, average fruit weight, vine length, number of female flowers per vine, number of fruits per vine, number of leaves per vine, number of branches per vine, fruit length and flesh thickness had positive direct effect on fruit yield per vine. Hence, these characters should be given prime importance in future breeding programme.





**Fig. 7: Powdery mildew incidence in 21 cucumber genotypes**

- Among 21 genotypes, 10 genotypes were highly resistant to fruit fly *viz.*, KRCCH-CC-3, KRCCH-CC-4, KRCCH-CC-5, KRCCH-CC-7, KRCCH-CC-9, KRCCH-CC-11, KRCCH-CC-12, KRCCH-CC-13, KRCCH-CC-14 and KRCCH-CC-18. Hence, these genotypes can be further used for resistance breeding.
- Out of 21 genotypes. 5 genotypes *viz.*, KRCCH-CC-1, KRCCH-CC-2, KRCCH-CC-4, KRCCH-CC-10 and KRCCH-CC-18 showed complete absence of powdery mildew. Hence, these genotypes can be utilized for further resistance breeding programme.

## 6. SUMMARY AND CONCLUSIONS

The present investigation on “Assessment of genetic variability in local collections of cucumber (*Cucumis sativus* L.) genotypes for productivity traits” was undertaken during the year 2017-2018 in *kharif* season at Kittur Rani Channamma College of Horticulture, Arabhavi. Twenty genotypes of cucumber along with check were evaluated in randomized complete block design (RCBD) with two replications. The experimental results are summarized below.

Analysis of variance revealed highly significant difference among the accessions for all the characters studied. Environmental influence was very less on expression of these characters as it was evident by narrow gap between genotypic and phenotypic coefficients of variation. Genotypic and phenotypic coefficients of variation were moderate to high for all the character studied except for days to first male flowering. High heritability coupled high genetic advance as per cent mean was obtained for all the characters indicating simple selection would be sufficient for these traits to bring genetic improvement.

Fruit yield per vine was found to be positively and significantly associated with number of female flowers per vine, vine length, number of leaves per vine and average fruit weight at both phenotypic and genotypic level. Strong association of these traits revealed that selection based on these traits would ultimately improve the fruit yield and it is also suggested that hybridization of genotypes possessing combination of such characters is most useful for obtaining desirable high yielding segregants.

Path coefficient analysis revealed that average fruit weight, vine length, number of female flowers per vine, number of fruits per vine, number of leaves per vine, number of branches per vine, fruit length and flesh thickness had positive direct effect on fruit yield per vine at both phenotypic and genotypic levels and most of the fruit related traits contributed to fruit yield mainly through average fruit weight and fruit length. Hence, it would be rewarding to lay stress on these characters in selection programmes for increasing yield.

Using Mahalanobis  $D^2$  statistic method, 20 genotypes along with Arabhavi local (check) were grouped into six divergent clusters. It is desirable to select genotypes from

clusters having higher inter-cluster distance and with high fruit yield as parents in the recombination breeding programmes.

Superior genotypes identified in this study are KRCCH-CC-17, KRCCH-CC-15, KRCCH-CC-13, KRCCH-CC-1 and KRCCH-CC-7. These genotypes have the desirable characteristics like high yield (KRCCH-CC-15 and KRCCH-CC-13) desirable fruit characteristics (KRCCH-CC-17, KRCCH-CC-7 and KRCCH-CC-1) and diverse nature (KRCCH-CC-17). These identified genotypes could be used for further improvement of the cucumber crop.

Three genotypes *viz.*, KRCCH-CC-4, KRCCH-CC-18 and KRCCH-CC-3 showed complete resistance to both fruit fly and powdery mildew incidence. Hence, these genotypes can be further utilized for resistance breeding.

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## Appendix- I

**Meterological data recorded during the period of experimentation (2017-2018)  
from Agriculture Research Station, Arabhavi.**

<b>Month</b>	<b>Maximum Temp. (°C)</b>	<b>Minimum Temp. (°C)</b>	<b>Rainfall (mm)</b>	<b>EVP (mm)</b>	<b>R.H. Max (%)</b>	<b>R.H Min (%)</b>
January 2017	31.40	9.90	0.00	1.90	88.90	58.00
February 2017	33.80	11.30	0.00	4.00	89.60	61.00
March 2017	41.20	19.50	0.00	4.40	85.10	68.20
April 2017	38.80	20.10	0.00	7.40	85.50	68.00
May 2017	39.40	22.80	10.20	6.80	84.80	60.20
June 2017	32.40	22.60	15.00	5.00	86.00	58.60
July 2017	31.00	21.30	37.20	3.50	91.10	63.50
August 2017	32.90	20.50	40.40	3.90	88.90	57.00
September 2017	33.10	19.40	179.40	3.70	93.60	71.30
October 2017	33.30	19.10	91.20	5.00	88.70	70.10
November 2017	33.40	12.40	8.20	4.10	78.00	65.00
December 2017	33.70	10.50	3.20	3.80	78.00	60.50
January 2018	32.30	8.20	0.00	4.20	80.80	61.20

**Appendix II: *Per se* performance of cucumber genotypes for growth, earliness, yield, quality and seed parameters**

Variety	Vine length (cm)	Number of leaves per vine	Number of branches per vine	Number of nodes per vine	Node @ 1 <sup>st</sup> male flowering	Node @ 1 <sup>st</sup> female flowering	Days to 1 <sup>st</sup> male flowering	Days to 1 <sup>st</sup> female flowering	Days to 50% flowering	Number of male flowers	Number of female flowers	Sex ratio
KRCCH-CC-1	177.00	117.00	3.45	11.62	2.05	2.85	26.00	31.00	40.50	98.25	10.50	9.65
KRCCH-CC-2	154.00	28.50	1.65	11.62	3.45	5.55	34.75	43.00	52.87	58.00	7.55	8.05
KRCCH-CC-3	103.75	33.50	4.20	10.75	2.80	5.15	35.50	41.50	53.62	47.80	8.87	5.50
KRCCH-CC-4	134.00	63.00	1.35	13.50	1.95	4.55	39.00	45.25	54.37	98.85	7.50	13.30
KRCCH-CC-5	190.50	57.50	2.75	15.87	3.95	6.45	33.75	40.50	49.25	79.55	10.75	7.50
KRCCH-CC-6	142.85	52.00	1.37	12.25	1.60	7.80	39.75	47.50	58.50	58.20	7.25	8.00
KRCCH-CC-7	111.50	72.50	2.85	9.25	3.50	5.55	35.50	43.85	54.62	81.35	5.65	15.35
KRCCH-CC-8	218.00	105.00	3.28	15.12	2.85	5.00	35.50	39.50	48.75	102.35	10.15	10.10
KRCCH-CC-9	168.35	58.50	2.85	15.25	3.90	4.77	39.50	48.00	58.25	67.85	6.50	10.60
KRCCH-CC-10	130.50	43.50	2.30	14.50	2.90	5.00	35.50	39.25	48.25	70.50	10.05	7.05
KRCCH-CC-11	159.00	102.50	3.55	12.50	3.45	5.90	36.50	45.25	55.75	76.50	5.35	14.65
KRCCH-CC-12	161.00	39.50	2.50	9.75	2.40	5.40	34.25	41.75	53.12	58.80	4.40	14.05
KRCCH-CC-13	168.50	58.00	3.30	10.50	3.45	5.00	39.25	42.75	52.50	58.85	7.65	7.80
KRCCH-CC-14	187.50	92.00	1.37	8.25	3.55	4.60	34.75	38.25	50.87	87.85	8.55	10.85

*Conti..*

Variety	Vine length (cm)	Number of leaves per vine	Number of branches per vine	Number of nodes per vine	Node @ 1 <sup>st</sup> male flowering	Node @ 1 <sup>st</sup> female flowering	Days to 1 <sup>st</sup> male flowering	Days to 1 <sup>st</sup> female flowering	Days to 50% flowering	Number of male flowers	Number of female flowers	Sex ratio
KRCCH-CC-15	154.40	79.00	4.42	10.25	1.50	3.65	38.25	44.25	49.00	65.85	9.80	6.85
KRCCH-CC-16	161.20	74.50	1.57	15.50	1.60	3.90	40.75	42.10	55.25	59.85	14.55	4.20
KRCCH-CC-17	125.75	50.50	4.72	11.00	1.40	4.75	30.50	42.25	58.62	59.90	12.50	4.90
KRCCH-CC-18	112.50	108.50	2.10	10.50	2.90	5.80	43.25	49.25	52.25	78.00	8.15	9.85
KRCCH-CC-19	170.25	50.50	1.80	10.50	1.50	3.20	33.75	39.25	61.85	56.35	6.20	9.50
KRCCH-CC-20	164.00	48.00	3.40	11.60	2.90	5.60	38.75	42.75	48.50	59.35	7.60	8.05
Arabhavi local (Check)	105.75	55.00	2.40	14.85	2.35	4.95	41.50	48.50	61.35	59.50	7.25	8.15
<b>Mean</b>	152.39	66.14	2.72	12.14	2.66	5.02	36.48	42.65	53.24	70.64	8.41	9.23
C.V. (%)	8.11	8.54	15.04	13.84	19.17	11.27	8.81	8.20	8.62	8.39	9.51	17.58
C D at 5%	25.78	11.79	0.85	3.50	1.06	1.18	6.70	7.30	9.58	12.37	1.67	3.38
C D at 1%	35.17	16.09	1.16	4.78	1.45	1.61	9.15	9.95	13.07	16.87	2.27	4.62

*Conti..*

Variety	Days to 1 <sup>st</sup> fruit harvest	Number of fruits per vine	Fruit Yield per vine (kg)	Average fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Flesh thickness (cm)	Seed yield per fruit (g)	Number of seed per fruit	Seed length (cm)	Seed width (cm)	Test weight (g)
KRCCH-CC-1	48.50	6.62	1.37	155.25	17.25	8.62	2.80	2.00	57.625	0.82	0.35	1.82
KRCCH-CC-2	50.85	4.12	1.10	177.25	22.50	5.00	2.45	3.15	123.50	1.16	0.47	2.20
KRCCH-CC-3	50.50	4.62	1.60	171.25	18.25	4.00	1.80	2.25	141.12	1.10	0.39	1.45
KRCCH-CC-4	52.00	3.87	1.05	211.80	21.50	5.50	2.00	2.35	142.75	0.64	0.47	1.50
KRCCH-CC-5	51.25	6.62	0.85	93.55	12.550	6.00	2.10	1.55	83.75	0.71	0.37	2.35
KRCCH-CC-6	61.75	3.75	1.47	349.00	21.05	6.65	1.85	6.75	257.75	1.10	0.32	2.85
KRCCH-CC-7	58.50	2.87	1.05	257.95	23.60	7.35	2.00	5.35	230.00	1.05	0.45	2.30
KRCCH-CC-8	51.50	4.75	1.80	263.25	20.50	7.80	2.05	3.15	191.25	0.82	0.43	1.55
KRCCH-CC-9	53.75	2.75	0.62	128.00	16.05	4.95	2.05	2.35	105.37	0.71	0.47	2.15
KRCCH-CC-10	61.00	5.87	1.30	164.45	15.50	4.35	2.05	2.40	128.00	0.87	0.51	1.90
KRCCH-CC-11	53.30	3.87	0.62	161.50	19.50	5.00	2.22	2.50	135.05	0.72	0.52	2.02
KRCCH-CC-12	58.50	2.62	0.75	217.00	19.00	6.55	2.25	2.75	186.00	1.00	0.42	1.67
KRCCH-CC-13	60.00	6.62	2.10	265.75	21.65	5.35	2.20	5.10	194.75	0.85	0.50	2.35
KRCCH-CC-14	52.00	4.87	1.07	160.10	22.05	7.65	1.57	4.05	148.50	0.75	0.42	2.57

*Conti..*

Variety	Days to 1 <sup>st</sup> fruit harvest	Number of fruits per vine	Fruit Yield per vine (kg)	Average fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Flesh thickness (cm)	Seed yield per fruit (g)	Number of seed per fruit	Seed length (cm)	Seed width (cm)	Test weight (g)
KRCCH-CC-15	51.75	8.37	2.50	276.05	23.45	4.50	1.90	3.80	184.00	0.67	0.39	2.57
KRCCH-CC-16	48.00	9.37	1.47	127.55	13.00	4.70	1.50	2.30	96.00	0.82	0.51	2.52
KRCCH-CC-17	48.00	9.62	1.27	225.05	26.20	7.75	2.30	3.75	184.35	0.83	0.32	2.00
KRCCH-CC-18	49.00	5.37	1.55	238.55	7.00	6.00	2.25	2.05	130.50	0.85	0.32	2.20
KRCCH-CC-19	51.50	5.12	1.10	201.55	6.00	6.15	1.65	2.60	165.50	0.77	0.47	2.47
KRCCH-CC-20	54.50	6.00	1.15	157.20	7.00	6.70	2.32	4.20	146.50	0.77	0.41	2.05
Arabhavi local (Check)	54.50	5.10	0.61	183.85	15.85	4.15	1.27	0.42	101.70	0.87	0.44	0.55
<b>Mean</b>	53.40	5.37	1.25	199.32	17.59	5.93	2.02	3.08	149.23	0.85	0.42	2.03
C.V. (%)	7.14	8.45	8.85	12.58	11.17	11.06	14.86	9.59	9.57	13.46	13.91	11.32
C D at 5%	7.95	0.94	0.23	52.33	4.09	1.37	0.62	0.61	29.79	0.24	0.12	0.48
C D at 1%	10.85	1.29	0.31	71.39	5.59	1.86	0.85	0.84	40.64	0.32	0.16	0.65

**ASSESSMENT OF GENETIC VARIABILITY IN LOCAL COLLECTIONS OF  
CUCUMBER (*Cucumis sativus* L.) GENOTYPES FOR PRODUCTIVITY  
TRAITS**

**MEENAKSHI S DODDAMANI**

**2018**

**Dr. SATISH D.**

**Major Advisor**

**ABSTRACT**

A field experiment was undertaken during the year 2017-2018 in *kharif* season to study the genetic variability, correlation, path co-efficient analysis and genetic diversity for productivity traits in 21 local collections of cucumber genotypes. The experiment was laid out in randomized block designs with two replications.

Analysis of variance revealed highly significant difference among the genotypes for all the traits studied. Wide range of variability, high heritability and high genetic advance as per cent over mean was observed for vine length, number of leaves per vine, number of branches per vine, node at first male flower, node at first female flower, number of male flowers, number of female flowers, fruit diameter, number of fruits per vine, average fruit weight, fruit yield per vine, fruit length, number of seeds per fruit, seed yield per fruit and test weight indicating predominant additive gene action offering scope for improvement of these characters through direct selection. Correlation studies revealed significant and positive association of fruit yield per vine with number of female flowers per vine, vine length, number of leaves per vine and average fruit weight. The maximum direct effect on fruit yield per vine was exhibited by average fruit weight followed by number of fruits per vine.

Mahalanobi's  $D^2$  analysis indicated presence of considerable diversity in cucumber genotypes and 21 genotypes were grouped into six clusters. The cluster II showed maximum (2242.20) intra cluster diversity. Inter cluster distance revealed the maximum divergence between clusters IV and cluster III ( $D^2 = 32489.21$ ) followed by cluster III and cluster II ( $D^2 = 24315.24$ ). Among all the 19 productivity traits studied, flesh thickness, fruit diameter, fruit length and average fruit weight contributed greatly towards divergence. The genotype KRCCH-CC-17 in cluster V recorded highest cluster mean. KRCCH-CC-8, KRCCH-CC-18, KRCCH-CC-3, KRCCH-CC-13 are some of the top high yielding genotypes. These, genotype can be used as a base material for future breeding programme.

**' ÉvÉiÁ (PÁÁKÁ i , ÁÉÁ J -i) , ÁÁiÁ , ÁÜÁÜÁÁé GvÁzPÁÉÜÁ ©PÁÜÁ  
CÉÁÁ²PÁÉzÁÜÁÁÁ ÁÁPÁÁ**

**«ÁÉÁÖé ²ÁÁÉÁZÁÉqÁÁ**

**2018**

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ÉvÁiÁ vÁUÁPÉ CÉÁÁ²PÁ ÁÁÁ. ÁÉzÁÉ ZÁÁgÁ«PÉ ÁÁÁÜ ©PÁÜÁÁ PÁÁÉÁÜÁ  
CzÁÁiÁÉPÉÁB ÖvÉÁgÁ gÁÁÁ ZÉÁÁÁ vÉÁi ÜÁj PÉ ÁÁÁ«ZÁÁÁÁ, CgÁÁ«ÁiÁ eÉ«PÁ vÁvÉÁÉÁ  
ÁÁÁÜ vÁÜ ÁZÁgÁÉ «ÁÜÁZPÉ ÉÉÁÁ-ÁvÁ. ««ZÁ ÁÜÁzÁ ÜÁÜÉÁZÁ ÉvÁiÁ 21 vÁz  
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SÁCZÉ

ÜÁÜÁÜÁ ÁgÁj ÁSÁZÁ ÁvÁÜ ÁÁ «ÁÁÜÉ ÁPÁVÁÁÜÁ ÁÁgÁ ÁZÁ PÁ-ÁÜÁÁ  
É¼ÁÁj ÁiÁÁ ÉÁÁgÁ ÁZÁ ÜÁÜÁÜÁÁÁ ÁÉÜÁ ÁÉÜÁ ÁSÁ ÁÉ S½ÁiÁ GzÁ ÁvÁÜ ÁgÁj  
ÁÁÉÁ vÉPÁÁ ÜÁÁÁiÁ ZÉÁvÁ ÁvÁÜ ÁÁÁÁ ÁZÁ ÁÁiÉÁÉÁÁÁÁ ÁÁÁÁÁÉ ÁÜÁÁ F J-ÁÉ  
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GÁÁiÁÁPÁÁvÁÉ

ÁÁÁÁÁÁÁÁÁ ÁgÁj ÁÁZÁ ZÁÉgÁ «ÁÁÜÉ CÉÁj 1, ÉvÁiÁ 21 vÁzÜÁÁÁ 6  
PÁÉÁÜÁÁv ÁvÁÁPj ÁÁvZÉ PÁÉÁÜÁ DÁvj PÁ ZÁÉgÁ DzÁgÁ ÁÁÁ-É PÁÉÁ-2 gPÉ Cw  
ÁZÁÁÁ CAVgÁ ÉgÁÁZÁ PÁqÁÁSÁCZÉ PÁÉÁÜÁ ÁZÁ ZÁÉgÁ DzÁgÁ ÁÁÁ-É PÁÉÁ-3  
ÁvÁÜ PÁÉÁ-4 gÁ ÁZÁ Cw ÁZÁÁÁÁ CAVgÁ PÁqÁÁSÁCZÉ CzÁÁiÁÁÁ ÁÁqPÁ Á MI ÁÜ 19  
GvÁZÉÁ ©PÁÜÁÁ ÁÁgÁ wÁÁÁÁ ÁÁÁ (72.86%), ÁÁÉÁ ÁÁÁ (17.14), ÁÁÉÁ GzÁ (7.62) ÁvÁÜ  
ÁgÁj ÁÁÉÁ vÉPÁ (1.43) ÜÁÁ «ÁÉÜÉ ÁZÁÁ PÉqÁÜÉ ÁÁÁÁ PÁÉÁ-5 gPÉÁ vÁz  
PÉDgí.1.1.ÁZi.-1.1.-17 CAVgÁ PÁÉÁ ÁgÁj ÁiÁÁÁÁ ZÁÁÁzÉ PÉDgí.1.1.ÁZi.-1.1.-8,  
PÉDgí.1.1.ÁZi.-1.1.-18, PÉDgí.1.1.ÁZi.-1.1.-3, PÉDgí.1.1.ÁZi.-1.1.-13 vÁzÜÁÁ ÁÁÉÁ  
É¼ÁÁj PÉqÁÁÁÁ DzÁj ÁZÁ ÁÁÁZÁ ÁÁ ÁvÁÉÁÁPÁÁÁ PÁÁiÁÁPÁÁÁ F vÁzÜÁÁÁÁ  
ÁÁÉÁÁÁÁ ÁÁÉÁ É¼ÁÁj ÁÁÁÁÁ ÁvÉ vÁzÜÁÁ CÁPÁÜÉ ÁÁÁÁÁÁÁÁÁÁÁÁ