The Pharma Innovation Journal 2022; 11(3): 2142-2147

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(3): 2142-2147
© 2022 TPI
www.thepharmajournal.com
Received: 10-12-2021
Accepted: 21-02-2022

Gurpiar Singh
Department of Vegetable Science, Khalsa College, Amritsar, Punjab, India

Navjot Singh Dhillon
Department of Vegetable Science, Khalsa College, Amritsar, Punjab, India

Corresponding Author:
Gurpiar Singh
Department of Vegetable Science, Khalsa College, Amritsar, Punjab, India

Genetic variability studies in parthenocarpic cucumber

Gurpiar Singh and Navjot Singh Dhillon

Abstract

The present experiment was undertaken with the objective to estimate nature of variation and associations among different horticultural traits. Ten parthenocarpic hybrids were raised in Randomised Block Design replicated thrice and data were recorded on marketable yield and its related traits. The results showed that Phenotypic Coefficient of Variation and Genotypic Coefficient of Variation estimates were high to moderate for vine length and number of female flowers per node. High heritability along with high genetic advance was recorded for internodal length, vine length, number of female flowers per node and total soluble solids. Genotypic correlation was higher than phenotypic correlation indicating highly heritable nature of these characters. The path coefficient analysis revealed that the number of fruits per plant, fruit weight, days taken to first fruit harvest and nodal position of first female flower had direct positive phenotypic and genotypic effect on the yield. Therefore, direct selection on the basis of number of fruits per plant and fruit weight will be rewarding for crop improvement in parthenocarpic cucumber.

Keywords: Correlation, genetic advance, heritability, path analysis

1. Introduction

Cucumber (*Cucumis sativus* L.) is an important vegetable crop cultivated all over the world, including India, with chromosomal number 2n=14. It is prominent member of the Cucurbitaceae family, which includes 117 genera and 825 species in warmer climates of the world (Nagamani *et al.* 2019) [17]. It is believed to have originated in India (De Condolle 1882) [6] and has been cultivated for at least 3000 years (Ullah *et al.* 2012) [29]. It is a thermophilic and frost-sensitive plant that thrives best in temperatures above 20˚ Celsius. It is the second most extensively grown cucurbit after watermelon. Cucumbers for pickling are preferred for processing, while cucumbers for slicing are planted for market purpose (Kumari *et al.* 2020) [16]. Cucumber is grown year-round to meet the demand for salads, sandwiches and pizza preparations under protected structures. Due to the vagaries of weather, variable moisture, and other factors, monoecious cucumber cultivated in an open field suffers from a number of problems, including a high incidence of red pumpkin beetle and fruit fly, as well as low quality including bitterness in the fruits (Sharma *et al.* 2019) [24]. Cucumber is a high-value, low-volume crop, therefore growing it on a commercial scale in a naturally ventilated polyhouse can boost yields. Information on the nature and magnitude of variation present in hybrids, heredity and genetic advance are necessary for an effective selection procedure. Correlation studies between various quantitative attributes can help to identify relation among the characters (Gangadhara *et al.* 2019) [4]. It could be used to develop effective selection strategies for increasing yield and quality. The path coefficient studies assist in assessing the direct and indirect contributions of various components in constructing the yield correlation. As a result, the current study was carried out to examine the variability and relationships between yield and quality variables in a protected structure.

2. Material and Methods

The current study was undertaken at the research farm of Department of Vegetable Science, Khalsa College Amritsar during 2020-21. Ten seedless hybrids were raised in Randomized Block Design (RBD) and replicated three times. Recommended package of practices were followed. Observations were recorded for the characters namely days to anthesis of first female flower, nodal position of first female flower, number of female flowers per node, days taken to first fruit harvest, fruit length, fruit girth, fruit weight, number of fruits per plant, marketable yield per plant, harvest duration, internodal length, vine length and total soluble solids. The coefficients of variation were determined as per Burton (1952) [3].

The heritability in broad sense and expected genetic advance expressed as percent of mean were calculated by using the formula given by Johnson *et al.* (1955) [12]. The correlation coefficient among all possible trait association at phenotypic and genotypic level were determined as given by Al-Jibouri *et al.* (1958) [2]. Path coefficient analysis as suggested by Wright (1921) [31] and Dewey and Lu (1959) [7].

3. Results and Discussion

3.1 Parameters of variability

The nature and extent of genetic variation in a crop is of foremost significance for choosing the best hybrids to increase production and its contributing attributes. The phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) estimates are useful for predicting the amount of variation present. For all of the characteristics, PCV estimations were greater than corresponding GCV, confirming that apparent variation is attributed to environmental factors rather than genotype alone.

3.1.1 Phenotypic coefficient of variation (%)

Vine length and number of female flowers per node had high phenotypic coefficients of variation whereas total soluble solids, internodal length, nodal position of first female flower, days to anthesis of first female flower, fruit girth, number of fruits per plant and marketable yield per plant had moderate PCV. PCV was low for harvest duration, fruit length, days taken to first fruit harvest and fruit weight. The results are in agreement with the findings of various researchers i.e. moderate estimates of PCV were reported for nodal position of first female flower (Sharma 2017) [25], number of fruits per plant (Singh *et al.* 2011, Sharma 2017) [25, 26], days to anthesis of first female flower (Dutta 2013) [9] and marketable yield per plant (Ullah *et al.* 2012, Kumar *et al.* 2013). [29, 15]

3.1.2 Genotypic coefficient of variation (%)

Since the phenotypic coefficient of variation on its own does not disclose the amount of variation hence numerous components of genetic parameters must be determined. Vine length, number of female flowers, internodal length, total soluble solids, and nodal position of first female flower all showed moderate GCV. Number of fruits per plant, fruit girth, marketable yield per plant, harvest time, fruit length, days to first fruit harvest, and fruit weight all indicated a low GCV.
The results are in consonance with various earlier workers i.e. low GCV was reported for fruit weight and fruit length (Sharma 2017) [25]. In contrary to our findings, low estimates of GCV were reported for vine length (Ranjan *et al.* 2015 [21], Pal *et al.* 2017) [18] and days to anthesis of first female flower (Ahirwar *et al.* 2018, Singh *et al.* 2018) [27]. Moderate GCV was observed for vine length (Ahirwar *et al.* 2018). For total soluble solids, internodal length, nodal position of first female flower and days to anthesis of first female flower, PCV and GCV were high to moderate, indicating substantial variability and ample scope for improvement through selection for these traits, whereas PCV and GCV were moderate for total soluble solids, internodal length, nodal position of first female flower and days to anthesis of first female flower, implying that these traits have less potential for direct selection. Harvest period, fruit weight, fruit length, and days to first fruit harvest have low PCV and GCV estimates, indicating limited genetic variation for these variables.

3.2 Heritability and genetic advance

3.2.1 Heritability (%): Heritability is a measure of heritable variation that aids in estimating amount of improvement obtained through selection. Internodal length, vine length, number of female flowers, total soluble solids, nodal position of first female flower, and harvest duration all had high heritability estimates. Fruit weight, fruit length, days to anthesis of first female flower, days to first fruit harvest and number of fruits per plant had moderate heredity estimates, however fruit girth and marketable yield per plant had low heritability values. High estimates for total soluble solids were reported by Shah *et al.* 2018 [23] and moderate heritability was recorded for days taken to first fruit harvest by Ahirwar *et al.* 2018, Shah *et al.* 2018 [23]. In contrary, the characters marketable yield per plant, number of fruits per plant showed high heritability (Gaikwad *et al.* 2011, Dutta 2013) [9, 10]. Environment had less influence on traits with high heritability estimates, therefore selection based on phenotypic performance would be reliable.

3.2.2 Genetic advance (per cent of mean)

High genetic advance was exhibited for vine length, number of female flowers per node, internodal length and total soluble solids. Harvest duration, number of fruits per plant, fruit girth, fruit length, marketable yield per plant, days to first fruit harvest and fruit weight showed moderate genetic advance while harvest duration, number of fruits per plant, fruit girth, fruit length, marketable yield per plant, days to first fruit harvest and fruit weight recorded the lowest genetic advance.
Similar to our research, total soluble solids exhibited high genetic advance (Shah *et al.* 2018) [23]. In contrary, high genetic advance existed for number of fruits per plant (Shah *et al.* 2018) [23] and marketable yield per plant (Choudhary *et al.* 2015 [5], Kandasamy 2017) [13] and moderate genetic advance was observed for vine length (Singh *et al.* 2017) [28]. Total soluble solids, vine length, internodal length, days to anthesis of first female flower, and nodal position of first female flower all had high to moderate heritability and genetic advance, indicating that the inheritance of these traits is controlled by additive gene action and that these traits can be improved through simple selection. Days to first fruit harvest, fruit length, fruit girth, fruit weight, number of fruits per plant and marketable yield per plant all had moderate to low heritability and low genetic advance, implying that these traits are inherited through non-additive gene action and that improvement through simple selection may not yield desirable results and these traits can be improved through recombinant breeding.

3.3 Correlation coefficient analysis

The nature of the association among yield and component attributes determines the efficacy of a selection or breeding programme, the more directly character is associated with yield in the desired direction, the greater the selection program's success. The magnitude of genotypic correlation coefficients was greater than that of phenotypic correlation coefficients, implying that while there is a strong underlying genotypic association between the traits assessed, the phenotypic expression of the correlation is lessened by environmental factors.

3.3.1 Phenotypic coefficient correlation

As shown in the table, marketable yield per plant exhibited significant positive correlation with number of fruits per plant. Among other traits, days to anthesis off first female flower had significant positive correlation with days taken to first fruit harvest, harvest duration, nodal position of first female flower, vine length, internodal length and number of female flowers per node. A significant and positive correlation of nodal position of first female flower was reported with days taken to first fruit harvest, harvest duration, number of female flowers per node, internodal length and vine length. Number of female flowers per node was positively and significantly correlated with harvest duration, days taken to first fruit harvest, vine length and internodal length. Days taken to first fruit harvest was positively correlated with harvest duration, internodal length and vine length. Fruit length exhibited positive and significant correlation number of fruits per plant and significant negative correlation with fruit girth, total soluble solids and fruit weight whereas fruit girth showed significant positive correlation with fruit weight. Number of fruits per plant had significant and positive correlation with harvest duration and harvest duration was positively and significantly correlated with internodal length and vine length. A significant and positive correlation of internodal length with vine length and vine length with total soluble solids was reported. Earlier workers also observed significant and positive correlation of marketable yield per plant with number of fruits per plant (Qian *et al.* 2002 [20], Dhiman and Chander 2005) [8].

3.3.2 Genotypic correlation coefficient

At genotypic level, marketable yield per plant had significant positive correlation with number of fruits per plant, harvest duration, days taken to first fruit harvest, days to anthesis of first female flower, fruit length, number of female flowers per node and internodal length whereas exhibited significant negative correlation with total soluble solids. Among other traits, days to anthesis of first female flower exhibited positive significant correlation with nodal position of first female flower, days taken to first fruit harvest, harvest duration, number of female flowers per node, internodal length, vine length and number of fruits per plant. Nodal position of first female flower showed significant positive correlation with days taken to first fruit harvest, number of female flowers per node, harvest duration, vine length, internodal length and total soluble solids. Significant negative correlation of this trait was observed with fruit weight. Number of female flowers per node exhibited significant and positive correlation with days taken to first fruit harvest, vine length, harvest duration, internodal length, number of fruits per plant and total soluble solids. Days taken to first fruit harvest had significant positive correlation with harvest duration, internodal length, vine length and number of fruits per plant. Fruit length showed significant and positive correlation with number of fruits per plant whereas it had negative correlation with fruit girth, total soluble solids, vine length and fruit weight. Fruit girth was positively and significantly correlated with total soluble solids, fruit weight and vine length whereas negative correlation with number of fruits per plant. Fruit weight exhibited negative significant correlation with number of fruits per plant and internodal length. Number of fruits per plant showed significant positive correlation with harvest duration and internodal length whereas it was negatively correlated with total soluble solids. Harvest duration exhibited significantly positive correlation with internodal length and vine length. Internodal length was positively and significantly correlated with vine length and vine length showed significant positive correlation with total soluble solids. Kumar *et al.* (2011) [14] reported positive significant correlation of fruit length with number of fruits per plant. Verma (2003) [30] observed positive significant correlation of days to anthesis of first female flower with days taken to first fruit harvest at both phenotypic and genotypic levels. Singh *et al.* (2017) [28] reported positive significant correlation of days to anthesis of first pistillate flower with days taken to first fruit harvest and negative association of marketable yield per vine with total soluble solids.

3.4 Path coefficient analysis

The correlation coefficient is partitioned into direct and indirect effects of parameters contributing to the dependent variable using path coefficient analysis. The direct and indirect effects found at the genotypic level differed from those found at the phenotypic level, which could be due to environmental influences on the traits investigated.

3.4.1 Estimates of direct effects at phenotypic and genotypic level

Direct positive effect on marketable yield per vine was shown by number of fruits per plant, fruit weight, days taken to first fruit harvest and nodal position of first female flower whereas negative direct effect was exhibited by number of female flowers per node, fruit length, internodal length and days to anthesis of first pistillate flower on marketable yield per plant at both phenotypic and genotypic level. Earlier researchers also observed direct and positive effects of number of fruits per plant (Qian *et al.* 2002 [20], Chander and Dhiman 2005) [8], fruit weight (Qian *et al.* 2002) [20], nodal position of first female flower (Rao *et al.* 2004) [22] and days taken to first fruit harvest (Singh *et al.* 2017) [28]. Maximum direct effect on marketable yield exerted by number of fruits per plant followed by fruit weight (Hasan *et al.* 2015 [11], Ahirwar *et al.* 2017 [1], Singh *et al.* 2017) [28].

3.4.2 Estimates of indirect effects at phenotypic and genotypic level

Positive significant indirect effect on marketable yield per vine was exhibited by number of fruits per plant at both phenotypic and genotypic levels.

Table 1: Assessment of PCV, GCV, heritability and genetic advance for marketable yield and related traits in parthenocarpic cucumber

Traits	PCV (%)	GCV (%)	h^2_{bs} (%)	GA
Days to anthesis of first female flower	13.54(M)	10.68(M)	62.21(M)	17.35(M)
Nodal position of first female flower	14.01(M)	12.24(M)	76.24(H)	22.01(M)
Number of female flowers per node	20.30(H)	18.21(M)	80.46(H)	33.64(H)
Days taken to first fruit harvest	7.86(L)	5.76(L)	53.75(M)	8.70(L)
Fruit length (cm)	8.59(L)	6.81(L)	62.82(M)	11.12(L)
Fruit girth (cm)	12.73(M)	8.48(L)	44.35(L)	11.63(L)

Fruit weight (g)	4.59(L)	3.76(L)	66.83(M)	6.33(L)
Number of fruits per plant	12.54(M)	8.95(L)	50.98(M)	13.17(L)
Marketable yield per plant (kg)	12.10 (M)	7.79 (L)	41.44 (L)	10.33(L)
Harvest duration (days)	8.83(L)	7.62(L)	74.42(H)	13.54(L)
Internodal length (cm)	18.01(M)	16.75(M)	86.46(H)	32.08(H)
Vine length (m)	21.35(H)	19.27(M)	81.46(H)	35.83(H)
Total soluble solids (˚brix)	18.45(M)	16.31(M)	78.12(H)	29.69(H)

PCV: Phenotypic Coefficient of Variation {>20%-High (H), 10-20%-Moderate (M), <10%-Low (L)} GCV: Genotypic Coefficient of Variation {>20%-High (H), 10-20%-Moderate (M), <10%-Low (L)} h^2bs (%): Heritability in broad sense {>70%-High (H), 50-70%-Moderate (M), <50%-Low (L) Genetic Advance (%) of mean {>25%-High (H), 15-25%-Moderate (M), <15%- Low (L)}

Table 2: Estimation of correlation coefficients at phenotypic (P) and genotypic (G) levels among different horticultural traits in parthenocarpic cucumber genotypes

	Nodal position of first female flower	**Number of female flowers per node**	**Days taken to first fruit harvest**	**Fruit length (cm)**	**Fruit girth (cm)**	**Fruit weight (g)**	**Number of fruits per plant**	**Harvest duration (days)**	**Internodal length (cm)**	**Vine length (m)**	**Total soluble solids (˚Brix)**	**Marketable yield per plant (kg)**
Days to anthesis of P female flower G	0.914** 0.995**	0.750** 0.937**	0.980** 0.983**	0.195 -0.176	-0.273 0.173	-0.287 -0.194	0.239 0.543**	0.923** 0.957**	0.799** 0.856**	0.801** 0.779**	0.176 0.217	0.134 0.523*
Nodal position of first P Female flower G		0.822** 0.926**	0.878** 0.963**	0.121 -0.168	-0.181 0.023	-0.302 -0.389*	0.194 0.335	0.854** 0.892**	0.806** 0.794**	0.782** 0.825**	0.311 0.398*	0.085 0.194
Number of female flower P per node G			0.721** 0.922**	-0.007 -0.101	-0.046 0.120	-0.200 -0.256	0.307 0.530**	0.766** 0.866**	0.646** 0.705**	0.746** 0.883**	0.310 0.413*	0.236 0.479**
Days taken to first fruit P Harvest G				0.243 -0.151	-0.321 0.141	-0.305 -0.220	0.275 0.611**	0.925** 0.981**	0.766** 0.836**	0.759** 0.755**	0.099 0.123	0.168 0.595**
Fruit length (cm) P G					-0.786** -0.976**	-0.439* -0.558**	0.460* 0.701**	0.338 0.181	0.144 -0.009	-0.247 -0.624**	-0.650** -0.946**	0.303 0.522**
Fruit girth (g)P G						0.769** 0.882**	-0.327 -0.639**	-0.348 -0.109	-0.205 -0.066	0.101 0.575**	0.358 0.897**	-0.052 -0.308
Fruit weight (g) PG							-0.259 -0.448*	-0.281 -0.258	-0.322 -0.371*	-0.103 0.015	0.023 0.219	0.098 -0.044
Number of fruits per plant P G								0.395* 0.733**	0.346 0.561**	-0.007 0.049	-0.299 -0.700**	0.935** 0.912**
Harvest duration (days) P G									0.735** 0.721**	0.635** 0.591**	-0.043 -0.068	0.299 0.711**
Internodal length (cm) PG										0.674** 0.675**	0.139 0.162	0.227 0.448**
Vine length (m) PG											0.546** 0.665**	-0.048 0.063
Total soluble solids (˚Brix) PG												-0.291 -0.694**

*Significance at 5% level of significance **Significance at 1% level of significance

Table 3: Estimation of direct and indirect effects of different traits on marketable yield per plant at phenotypic (P) and genotypic (G) levels in parthenocarpic cucumber genotypes

	Days to anthesis of first female flower	**Nodal position of first female flower**	**Number of female flowers per node**	**Days taken to first fruit harvest**	**Fruit length (cm)**	**Fruit girth (cm)**	**Fruit weight (g)**	**No. Of fruits per plant**	**Harvest duration (days)**	**Internodal length (cm)**	**Vine length (m)**	**Total soluble solids (˚Brix)**	**r**
Days to anthesis of first P female flower G	-0.108 -0.174	0.049 0.075	-0.027 -0.025	0.068 0.165	-0.006 0.008	0.004 -0.003	-0.105 -0.092	0.250 0.632	0.019 -0.020	-0.026 -0.041	0.015 -0.003	0.00002 -0.0002	0.134 0.523*
Nodal position of first P female flower G	-0.098 -0.174	0.054 0.075	-0.030 -0.024	0.061 0.162	-0.004 0.007	0.003 0.0004	-0.110 -0.183	0.204 0.390	0.017 -0.018	-0.026 -0.038	0.015 -0.003	0.00004 -0.0004	0.085 0.194
Number of female flowers P per node G	-0.081 -0.163	0.044 0.070	-0.036 -0.026	0.050 0.155	0.0002 0.004	0.001 -0.002	-0.073 -0.121	0.322 0.617	0.015 -0.018	-0.021 -0.033	0.014 -0.003	0.00004 -0.0004	0.236 0.479**
Days taken to first P fruit harvest G	-0.105 -0.171	0.047 0.073	-0.026 -0.024	0.070 0.168	-0.008 0.007	0.005 -0.002	-0.111 -0.104	0.289 0.712	0.019 -0.020	-0.025 -0.040	0.014 -0.003	0.00001 -0.0001	0.168 0.595**
Fruit length (cm) P G	-0.021 0.031	0.006 -0.013	0.0003 0.003	0.017 -0.025	-0.032 -0.044	0.011 0.017	-0.160 -0.263	0.483 0.816	0.007 -0.004	-0.005 0.0004	-0.005 0.002	-0.00008 0.0010	0.303 0.522**
Fruit girth (cm) P G	0.029 -0.030	-0.010 0.002	0.002 -0.003	-0.022 0.024	0.025 0.043	-0.014 0.017	0.280 0.416	-0.343 -0.745	-0.007 0.002	0.007 0.003	0.002 -0.002	0.00004 -0.0009	-0.052 -0.308
Fruit weight (g) P G	0.031 0.034	-0.016 -0.029	0.007 0.007	-0.021 -0.037	0.014 0.024	-0.011 -0.015	0.364 0.472	-0.272 -0.522	-0.006 0.005	0.010 0.018	-0.002 0.0001	0.00000 -0.0002	0.098 -0.044

Number Of fruits per plant P G	-0.026 -0.095	0.010 0.025	-0.011 -0.014	0.019 0.103	-0.015 -0.031	0.005 0.011	-0.094 -0.212	1.050 1.165	0.008 -0.015	-0.011 -0.027	0.0001 0.0002	-0.00004 0.0007	0.935** 0.912**
Harvest duration (days) P G	-0.099 -0.167	0.046 0.067	-0.028 -0.023	0.065 0.165	-0.011 -0.008	0.005 0.002	-0.102 -0.122	0.415 0.854	0.020 -0.020	-0.024 -0.034	0.012 -0.002	-0.00001 0.0001	0.299 0.711**
Internodal length (cm) P G	-0.086 -0.149	0.043 0.060	-0.023 -0.019	0.054 0.141	-0.005 0.080	0.003 0.001	-0.117 -0.175	0.363 0.653	0.015 -0.015	-0.032 -0.047	0.013 -0.003	0.00002 -0.0002	0.227 0.448**
Vine length (m) P G	-0.086 -0.136	0.042 0.062	-0.027 -0.023	0.053 0.127	0.008 0.027	-0.001 -0.010	-0.038 0.007	-0.008 0.057	0.013 -0.012	-0.022 -0.032	0.019 -0.004	0.00006 -0.0007	-0.048 0.063
Total soluble solids P (˚Brix) G	-0.019 -0.038	0.017 0.030	-0.011 -0.011	0.007 0.021	0.021 0.041	-0.005 -0.015	0.008 0.103	-0.314 -0.816	-0.001 0.001	-0.005 -0.008	0.010 -0.003	0.00012 -0.0010	-0.291 -0.694**

Significance at $P \leq 0.01$; *Significance at $P \leq 0.05$, Residual effect (P) = 0.00077; (G) = -0.00042; The bold values indicates direct effects; P = Phenotypic level and G = Genotypic level; r = correlation coefficient with marketable yield per plant

3.5 Conclusion

High to moderate PCV and GCV estimates for vine length and number of female flowers per node were found indicating presence of variability ensuring ample scope for improvement through selection. High heritability along with high genetic advance were resulted for traits *viz*., internodal length, vine length, number of female flowers per node and total soluble solids indicating the importance of additive gene action for inheritance of these traits and further improvement can be done through phenotypic selection. The genotypic correlation was higher than the phenotypic correlation showing that all the attributes are highly heritable. The number of fruits per plant was found to have a highly significant positive relationship with marketable yield per plant implying that direct selection based on these features will boost fruit yield. The number of fruits per plant, fruit weight, days to first fruit harvest and nodal position of first female flower all exhibited a direct positive phenotypic and genotypic effect on yield, as per path coefficient analysis. These studies demonstrated that crop improvement in seedless cucumber can be achieved by selecting plants based on the number of fruits per plant and the weight of the fruits.

4. References

1. Ahirwar CS, Singh DK, Kushwaha ML. Assessment of genetic variation in cucumber (*Cucumis sativus* L.) germplasm on correlation, path analysis and cluster analysis. Chemical Science Review and Letters. 2017;(6):1886-1893.
2. Al-Jibouri HW, Miller PA, Robinson HF. Genotypic and environmental variances and co-variances in an upland cotton cross of interspecific origin. Agronomy Journal. 1958;(50):633-636.
3. Burton GW. Quantitative inheritance in grasses. In: Proceedings of 6th International Grassland Congress. 1952;(1):277-283.
4. Gangadhara K, Kumar R, Selvakumar R, Apparao VV, Yadav LP. Evaluation of cucumber hybrids/lines for yield and quality under polyhouse. International Journal of Current Microbiology and Applied Science. 2019;(8):1652-1661.
5. Choudhary H, Singh DK, Damke SR. Genetic variability in *Cucumis sativus* var. *hardwickii* key to cucumber improvement. International Journal of Applied Agricultural Sciences. 2015;(13):340-343.
6. De Candolle A. *Origine des plantescultive Germes Bailliere.* Paris 1882, p 377.
7. Dewey DR, Lu KH A. Correlation and path coefficients analysis of crested wheat grass seed production. Agronomy Journal. 1959;(51):515-18.
8. Dhiman MR, Chander P. Correlation and path coefficient analysis in cucumber. Haryana journal of horticultural sciences. 2005;(34):111-112.
9. Dutta RK. Study on genetic variability, heritability, genetic advance, correlation and path coefficient analysis in diverse genotypes of cucumber (Cucumis sativus L.) M.Sc. Thesis, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India. 2013, p 49.
10. Gaikwad AG, Sonawane HG, Dhumal SS, Musmade AM. Variability studies in cucumber (*Cucumis sativus* L.). The Asian Jounal of Horticulture. 2011;(6):148-150.
11. Hasan R, Hossain MK, Alam N, Bashar A, Islam S, Tarafder MJA. Genetic divergence in commercial cucumber (*Cucumis sativus* L.) genotypes. Bangladesh Journal of Botany. 2015;(44):201-207.
12. Johnson HW, Robinson HF and Comstock RE. Estimates of genetic and environmental in soybean. Agronomy Journal. 1955;(47):314-18.
13. Kandasamy R. Variability studies in cucumber (*Cucumis sativus* L.). The Asian Jounal of Horticulture. 2017;(12):84-87.
14. Kumar AKH, Patil MG, Hanchinamani CN, Goud IS, Hiremath SV. Genetic relationship of growth and development traits with fruit yield in F_2 population of BGDL × Hot Season of cucumber (*Cucumis sativus* L.). Karnataka Journal of Agricultural Sciences. 2011;(24):497-00.
15. Kumar S, Kumar D, Kumar R, Thakur KS, Dogra BS. Estimation of Genetic Variability and Divergence for Fruit Yield and Quality Traits in Cucumber (*Cucumis sativus* L.) in North-Western Himalays, Universal Journal Of Plant Science. 2013;(1):27-36.
16. Kumari M, Ram CN, Nath S, Maurya N, Kumar S. Studies on genetic variability, heritability and genetic advance in cucumber (*Cucumis sativus*) Journal of pharmacognosy and phytochemistry. 2020;(9):481-484.
17. Nagamani GV, Kumar JSA, Reddy TBM, Rajesh AM, Amarananjundeswara H, Reddy RLR. *et al*. Performance of different parthenocarpic cucumber (*Cucumis sativus* L.) hybrids for yield and yield attributing traits under shade net house. International Journal of Current Microbiology and Applied Science. 2019;(8):978-982.
18. Pal S, Sharma H R and Yadav N Evaluation of cucumber genotypes for yield and quality traits. Journal of Hill Agriculture. 2017;(8):144-5.
19. Panse VG, Sukhatme PV. *Statistical Methods for Agricultural Workers*. Indian Council of Agricultural Research, Publication, New Delhi. 1984, 359.
20. Qian ZY, Cai R, He HL, Pan JS. Study on genetic correlation and path analysis of the main agronomic

characters of gynoecious parthenocarpic cucumber. Journal of Shanghai Jiaotong University (Agricultural Science). 2002;(20):133-136.

21. Ranjan P, Gangopadhyay KK, Bag MK, Roy A, Srivastava R, Bhardwaj R, *et al.* Evaluation of cucumber (*Cucumis sativus* L.) germplasm for agronomic traits and disease resistance and estimation of genetic variability. The Indian Journal of Agricultural Sciences. 2015;(85):234-239.
22. Rao ES, Munshi AD, Verma VK. Genetic association and interrelationship of yield and its components in cucumber (*Cucumis sativus* L.). International Journal of Horticultural Sciences. 2004;(61):315-318.
23. Shah KN, Rana DK, Singh V. Evaluation of genetic variability, heritability and genetic advance in cucumber (*Cucumis sativus* L.) for various quantitative, qualitative and seed characters. International Journal of Current Microbiology and Applied Science. 2018;(7):3296-3303.
24. Sharma P, Dhillon NS, Kumar P, Mehta P. Evaluation of parthenocarpic cucumber genotypes for yield and its contributing traits under protected environment of N-W Himalayas. International journal of chemical studies 2019;(3):4-6.
25. Sharma S. Genetic divergence studies in cucumber (*Cucumis sativus* L.). M.Sc. Thesis, Department of Vegetable Science, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan, India. 2017, p60.
26. Singh SK, Singh A, Gangwar LK. Variability and heritability studies in cucumber. Progressive Agriculture. 2011;(11):166-167.
27. Singh SS, Yadav GC, Kathayat K. Study of genetic variability in cucumber. Journal of Hill Agriculture. 2018;(9):39-43.
28. Singh Y, Safiullah, Verma A, Sharma S, Sekhon BS. Genetic evaluation of cucumber (*Cucumis sativus* L.) genotypes for yield and its contributing traits under mid-hill conditions of Himachal Pradesh, Journal of Ecology and Environment. 2017;(35):3621-3626.
29. Ullah MZ, Hasan MJ, Chowdhury AZMKA, Saki AI, Rahman AHMA. Genetic variability and correlation in exotic cucumber (*Cucumis sativus* L.) varieties. Bangladesh Journal of Plant Breeding and Genetics. 2012;(25):17-23.
30. Verma S. Genetic variability and correlation studies in cucumber (*Cucumis sativus* L.). M.Sc. Thesis, p 44. Department of Vegetable Science, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan, India. 2003.
31. Wright S. Correlation and causation. Journal of agricultural research**.** 1921;(20):557-585.