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Majid Rashid
Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar, Jammu and Kashmir, India

KP Wani
Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar, Jammu and Kashmir, India

K Hussain
Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar, Jammu and Kashmir, India

ZA Dar
Division of Genetics and Plant Breeding, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar, Jammu and Kashmir, India

Syed Mazahir Hussain
Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar, Jammu and Kashmir, India

Muzamil Ahmad
Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar, Jammu and Kashmir, India

Insha Javeed
Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar, Jammu and Kashmir, India

Syeda Farwah
Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar, Jammu and Kashmir, India

Sameena Maqbool
Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar, Jammu and Kashmir, India

Corresponding Author:
Majid Rashid
Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar, Jammu and Kashmir, India

Correlation and path coefficient analysis for various traits in bottle gourd [*Lagenaria siceraria* (Molina) Standl.] genotypes

Majid Rashid, KP Wani, K Hussain, ZA Dar, Syed Mazahir Hussain, Muzamil Ahmad, Insha Javeed, Syeda Farwah and Sameena Maqbool

Abstract
The present investigation was carried out at the Experimental Field, Division of Vegetable Science, SKUAST-K, Shalimar during Kharief 2018. The experiment was laid out in randomized complete block design (RCBD) with three replications. Correlation and path analysis among different characters of thirty bottle gourd genotypes were studied. Observations revealed that fruit yield plant^{-1} was positively associated with traits like node number at which first male flower appeared, node number at which first female flower appeared, number of days to anthesis of first female flower, fruit diameter, dry matter content and total sugars. Moreover the traits like days to last fruit harvest and number of fruits plant^{-1} showed significant positive genotypic correlation with fruit yield plant^{-1} indicating that direct selection of these traits will be effective. Path coefficient analysis revealed appreciable amount of direct positive effects of component traits like node number at which first male flower appeared, days to anthesis of first female flower, days to last fruit harvest, number of fruits plant^{-1} and total sugars on fruit yield plant^{-1}.

Keywords: Correlation, selection, path analysis, bottle gourd

Introduction
Bottle gourd [*Lagenaria siceraria* (Molina) Standl.] (2n=2x=22) belongs to family Cucurbitaceae and is one of the most ancient crop cultivated during summer throughout the world. The genus *Lagenaria* is derived from the word lagena, meaning the bottle. It is also known as Calabash, Doodhi and Lauki in different parts of India (Deore *et al.*, 2009) [2]. Its primary centre of origin is Africa (Singh, 1990) [17]. The fossil records indicate its culture in India even before 2000 B.C. It is a highly cross pollinated crop due to its monoecious and andromonoecies nature (Swiander *et al.*, 1994) [18] and shows large amount of variation for various economic traits of which the most interesting variation is found for size, shape and colour of fruits. It has a good amount of vitamins and minerals. Its fruit contains 95.54%moisture, vitamin C (10.1 g), vitamin A (16 IU), thiamine (0.029 g), riboflavin (0.022 g), niacin (0.320 g), carbohydrates (3.39 g), fats (0.02 g) and potassium (150 mg)/100g (USDA, 2018) [22]. It is ideal for human food or for incorporation into livestock feed (Ogunbusola *et al.*, 2010) [13]. It is easily digestible and is therefore recommended during convalescence. The dietary fiber present in the bottle gourd makes it a very useful vegetable in preventing digestive disorders such as constipation. A positive correlation has been found between fiber consumption and the reduction of coronary heart diseases and diabetes incidence (Hemeda *et al.*, 2008) [5]. Bottle gourd juice is used traditionally as a medicine for treating acidity, indigestion and ulcers besides being a good thirst quencher. The fruit is found to be antidote to certain poisons and scorpion stings, and also has purgative and cooling effects. The fruit is believed to have ability to relieve pain and is effective against fever, and hence found useful in treatment of asthma and other bronchial disorders. It is also a good source of natural antioxidants (Deore *et al.*, 2009) [2]. Genotypic, phenotypic and environmental correlations reveal the degree of association between different characters. Thus it helps to base selection procedure to a required balance when two opposite desirable characters affecting the principle character are being selected. It also helps to improve different characters simultaneously (Falconer, 1981) [4]. The other genetic parameter commonly used is the path analysis as given by Dewey and Lu (1959) [3]. Path analysis gives the cause and effect relationship. It critically breaks up different direct effect and indirect effect which finally makes up correlation coefficient.

Materials and Methods

The present investigation was carried out at Vegetable Experimental Farm, Division of Vegetable Science, SKUAST-Kashmir, Shalimar, Srinagar during *Kharief* 2018. The altitude of the location is 1685 meter above mean sea level and situated 34º N of latitude and 74.89º E of longitude. The climate is temperate characterized by mild summers. The mean minimum and maximum temperatures are recorded in months of January and June (respectively). The maximum rain fall is received during March to April. Thirty genotypes of bottle gourd were evaluated for various yield and yield attributing traits. A single factor experiment was laid out in randomized complete block design (RCBD) with three replications of each accession per plot. Plants from each genotype were transplanted at random to each block at spacing of 1 m between rows and 0.60 m between plants. Recommended package of practices were adopted to raise a healthy crop. The observations were recorded on node number at which first male flower appeared, node number at which first female flower appeared, days to anthesis of first male flower, days to anthesis of first female flower, days to first fruit harvest, days to last fruit harvest, fruit length, fruit diameter, number of fruits plant^{-1}, fruit yield plant^{-1}, fruit yield hectare^{-1}, dry matter content, total chlorophyll and total sugars. Estimate of genotypic and phenotypic variances and covariances were substituted in the formula suggested by Panse and Sukatme (1985) [14] to calculate correlation co-efficient between all possible pairs of characters. The methodology suggested by Wright (1921) [23] and Li (1956) [10] was adopted while using the formula given by Dewey and Lu (1959) [3] to carry out path coefficient analysis.

Results and Discussion

In the present study, thirty genotypes of bottle gourd were evaluated to estimate the correlation and path analysis. Correlation studies pave way to know the association prevailing between highly heritable characters with most economic characters and gives better understanding of the contribution of each trait in building up the genetic makeup of the crop. The phenotypic correlations indicate the extent of the observed relationship between two characters. This does not give true genetic picture of the relationship because it indicates both heritability as well as environmental influences. Genotypic correlations provide an estimate of inherent association between genes controlling any two characters. Hence, it is of greater significance and could be effectively utilized in formulating an effective selection scheme. Perusal (Table-1) indicated that in the present investigation, the estimates of genotypic correlation were in general slightly higher than phenotypic correlation showing that masking effects of the environment was little indicating the presence of inherent association between various characters. In all instances, however, more reliance may be placed on the genotypic correlations. The nature of genotypic correlation was more or less similar to phenotypic correlation under study. In case of phenotypic correlation, it was found that fruit yield plant^{-1} was positively associated with traits like node number at which first male flower appeared, node number at which first female flower appeared, days to anthesis of first female flower, days to last fruit harvest, fruit diameter, number of fruits plant^{-1} and total sugars. Similar findings were reported by Prasana *et al.* (2002), Kumar *et al.* (2007), Yadav *et al.* (2010) and Deepthi *et al.* (2012) [15, 9, 24, 1]. While in the case of genotypic correlation, fruit yield plant^{-1} was positively associated with traits like node number at which first male flower appeared, node number at which first female flower appeared, days to anthesis of first female flower, days to last fruit harvest, fruit diameter, number of fruits plant^{-1}, dry matter content and total sugars. These findings are in agreement with those of several researchers (Kumar *et al.*, 2007 and Yadav *et al.*, 2010) [9, 24].

Upon the assessment of apparent relationship between yield and yield components, it is necessary to partition the direct and indirect effects of each character on yield to understand the nature of association at genotypic and phenotypic level. In current study the path coefficient analysis (Table-3) revealed appreciable amount of direct positive effects of component traits like node number at which first male flower appeared, days to anthesis of first female flower, days to last fruit harvest, number of fruits plant^{-1} and total sugars on fruit yield plant^{-1}. Moreover from the above traits days to last fruit harvest and number of fruits plant^{-1} showed Significant positive genotypic correlation with fruit yield plant^{-1} indicating that direct selection of these traits will be effective in realizing improvements in fruit yield of bottle gourd. The direct effects of component traits like node number at which first female flower appeared, days to anthesis of first male flower, days to first fruit harvest, fruit length, fruit diameter, total chlorophyll and dry matter content were negative. Therefore these traits should be considered of little importance in the selection programme of bottle gourd. These results are in agreement with those reported by Narayan *et al.* (1996), Kumar and Singh (1998), Umamaheswarappa *et al.*(2004), Singh *et al.* (2006), Husna *et al.* (2011), Muralidharan *et al.*(2013), Janaranjani and Kanthaswamy (2015), Thakur *et al.*(2015) and Thakur *et al.*(2017) [12, 8, 21, 16, 6, 11, 7, 19, 20].

Table 1: Estimates of genotypic correlation coefficients among different characters in bottle gourd.

Parameters	NMA	NFA	DAM	DAF	DIFH	DLFH	FL	FD	NFPP	FYPP	TS	TC	DM	FYH
NMA	1.00	0.324**	-0.018	-0.049	-0.063	0.184	0.614**	-0.672**	0.258*	0.059	-0.030	-0.487**	-0.190	0.059
NFA		1.00	0.464**	0.356**	-0.156	-0.189	0.374**	-0.524**	0.151	0.065	0.070	-0.122	-0.413**	0.065
DAM			1.00	0.901**	-0.010	-0.284*	0.013	-0.092	-0.102	-0.072	0.204	-0.062	0.037	-0.072
DAF				1.00	-0.005	-0.253*	-0.072	0.091	-0.063	0.016	0.331**	-0.072	0.099	0.016
DIFH					1.00	-0.184	0.059	-0.183	-0.467**	-0.825**	0.075	0.047	-0.050	-0.825**
DLFH						1.00	0.230	0.078	0.382**	0.355**	-0.121	-0.017	0.278*	0.355**
FL							1.00	-0.662**	0.156	-0.040	0.202	-0.171	-0.413**	-0.040
FD								1.00	0.045	0.189	-0.083	0.313**	0.486**	0.189
NFPP									1.00	0.751**	-0.013	0.116	-0.184	0.751**
FYPP										1.00	0.114	-0.062	0.011	1.00
TS											1.00	-0.048	0.068	0.114
TC												1.00	-0.154	-0.062
DM													1.00	0.011

FYH														1.00

*, **= Significant at 5% and 1% respectively

NMA: Node no. at which first male flower appeared; NFA: Node no. at which first female flower appeared; DAM: Days to anthesis of first male flower; DAF: Days to anthesis of first female flower; DIFH: Days to first fruit harvest; DLFH: Days to last fruit harvest; FL: Fruit length (cm); FD: Fruit diameter (cm); NFPP: No. of fruits plant^{-1}; FYPP: Fruit yield plant^{-1} (kg); TS: Total sugars (%); TC: Total Chlorophyll (mg100g^{-1}); DM: Dry matter content (%); FYH: Fruit yield (qha^{-1})

Table 2: Estimates of phenotypic correlation coefficients among different characters in bottle gourd

Parameters	NMA	NFA	DAM	DAF	DIFH	DLFH	FL	FD	NFPP	FYPP	TS	TC	DM	FYH
NMA	1.00	0.329**	0.019	0.013	0.102	0.138	0.427**	-0.395	0.075	0.043	-0.027	-0.339**	-0.104	0.043
NFA		1.00	0.368**	0.322**	-0.111	-0.168	0.297**	-0.393**	0.054	0.045	0.056	-0.117	-0.291**	0.045
DAM			1.00	0.846**	0.038	-0.265*	0.017	-0.072	-0.073	-0.005	0.177	-0.003	0.012	-0.005
DAF				1.00	0.080	-0.215*	-0.052	0.106	-0.065	0.063	0.283**	-0.034	0.070	0.063
DIFH					1.00	-0.103	0.049	-0.127	-0.406**	-0.640**	0.096	-0.020	-0.017	-0.640**
DLFH						1.00	0.192	0.059	0.263*	0.254*	-0.068	-0.021	0.256*	0.254*
FL							1.00	-0.632**	0.122	-0.017	0.175	-0.102	-0.373**	-0.017
FD								1.00	0.029	0.149	-0.093	0.138	0.449**	0.149
NFPP									1.00	0.669**	-0.078	0.001	-0.182	0.669**
FYPP										1.00	0.042	-0.004	-0.021	1.00**
TS											1.00	-0.002	0.081	0.042
TC												1.00	-0.102	-0.004
DM													1.00	-0.021
FYH														1.00

*, **= Significant at 5% and 1% respectively

NMA: Node no. at which first male flower appeared; NFA: Node no. at which first female flower appeared; DAM: Days to anthesis of first male flower; DAF: Days to anthesis of first female flower; DIFH: Days to first fruit harvest; DLFH: Days to last fruit harvest; FL: Fruit length (cm); FD: Fruit diameter (cm); NFPP: No. of fruits plant^{-1}; FYPP: Fruit yield plant^{-1} (kg); TS: Total sugars (%); TC: Total Chlorophyll (mg100g^{-1}); DM: Dry matter content (%); FYH: Fruit yield (qha^{-1})

Table 3: Path coefficient analysis among different characters in bottle gourd

Parameters	NMA	NFA	DAM	DAF	DIFH	DLFH	FL	FD	NFPP	TS	TC	DM	FYPP
NMA	0.0139	-0.0217	0.0000	-0.0048	-0.0054	0.0379	-0.0774	0.0091	0.0760	-0.0046	0.0339	0.0171	0.059
NFA	0.0045	-0.0660	-0.0585	0.0817	0.0813	-0.0327	-0.0497	0.0079	0.0492	0.0093	0.0099	0.0410	0.065
DAM	0.0000	-0.0277	-0.1394	0.2115	-0.0054	-0.0509	-0.0337	0.0013	-0.0402	0.0312	0.0033	-0.0034	-0.072
DAF	-0.0002	-0.0224	-0.1227	0.2403	-0.0163	-0.0436	0.0087	-0.0016	-0.0313	0.0241	0.0041	-0.0102	0.016
DIFH	0.0001	0.0092	-0.0013	0.0072	-0.5439	-0.0273	-0.0087	0.0027	-0.2818	0.0124	-0.0016	0.0045	-0.825
DLFH	0.0022	0.0118	0.0390	-0.0576	0.0815	0.1820	-0.0321	-0.0011	0.1476	-0.0156	0.0466	-0.0307	0.355
FL	0.0073	-0.0224	-0.0013	-0.0144	-0.0326	0.0400	-0.1461	0.0110	0.0626	0.0296	0.0115	0.0456	-0.040
FD	-0.0075	0.0310	0.0111	0.0332	0.0870	0.0127	0.0950	-0.0169	0.0178	-0.0140	-0.0190	-0.0535	0.189
NFPP	0.0023	-0.0072	0.0534	-0.0168	0.2393	0.0600	-0.0204	-0.0006	0.4473	-0.0062	-0.0049	0.0205	0.751
TS	-0.0004	-0.0039	-0.0278	0.0745	-0.0435	-0.0182	-0.0277	0.0352	-0.0178	0.1560	0.0024	-0.0091	0.114
TC	-0.0056	0.0079	0.0055	-0.0442	-0.0108	-0.0036	0.0204	-0.0038	0.0268	-0.0046	-0.0827	0.0148	-0.062
DM	-0.0020	0.0129	-0.0041	0.0216	0.0217	0.0491	0.0584	-0.0079	-0.0805	0.0124	0.0107	-0.1140	0.011

Residual effect = 0.20

NMA: Node no. at which first male flower appeared; NFA: Node no. at which first female flower appeared; DAM: Days to anthesis of first male flower; DAF: Days to anthesis of first female flower; DIFH: Days to first fruit harvest; DLFH: Days to last fruit harvest; FL: Fruit length (cm); FD: Fruit diameter (cm); NFPP: No. of fruits plant^{-1}; FYPP: Fruit yield plant^{-1} (kg); TS: Total sugars (%); TC: Total Chlorophyll (mg100g^{-1}); DM: Dry matter content (%)

Conclusion

Correlation studies indicated that characters *viz.*, days to last fruit harvest, number of fruit plant^{-1} and fruit yield plant^{-1} should be considered for improving quantitative traits in bottle gourd. Path coefficient analysis further suggested that number of fruits plant^{-1}, days to anthesis of first female flower, days to last fruit harvest and total sugars have highest direct effects on the fruit yield plant^{-1} and should be given due importance by selection for breeding of new cultivars.

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