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Correlation matrix study in bitter gourd for qualitative and quantitative traits

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Abstract
Twenty-one bitter gourd genotypes collected from different seed company and were evaluated under Randomized Block Design with three replications at Vegetable Research Farm, Bihar Agricultural University, Sabour during February month of 2016-17. An experiment was conducted to evaluate the morphological characters, fruit yield and biochemical traits of different bitter gourd genotypes. The pistillate flowers produced earlier than staminate flowers in the proximal node in some genotypes. The results revealed that small fruited genotype had larger number of fruits whereas larger size fruits had highest average weight. All the genotype shown wide range of scale for morphological and biochemical traits based on Duncan multiple range test. The biochemical traits shown considerable variation among the genotype. Phenotypic correlation matrix was higher than genotypic correlation matrix for all the traits. The variations in morphological, quantitative and biochemical traits attributes leads to development of high yielding variety for qualitative and quantitative traits through breeding techniques.

Keywords: Matrix study, bitter gourd, qualitative, quantitative traits

Introduction
The bitter gourd (*Momordica charantia* L.) belongs to Cucurbitaceae family as most important vegetables. It has ability to acclimatized in wide range of environments and can be grown in tropical and subtropical climates. It is more fascinated by the consumers due to its unique taste and high nutritional values. The fruits, leaves and the roots of *M. charantia* have been used for treatment of number of diseases such as a bitter stomachic, laxative and anthelmintic (Ullah *et al*., 2012) [7]. A compound known as 'charantin' present in the bitter gourd is used in the treatment of diabetes to reduce blood sugar level (Anunciado and Masangkay, 2002) [1]. The fruit has also rich amount of vitamin C, iron, phosphorus and carbohydrates (Behera, 2004) [2]. Bitter gourd is a monoecious plant having greater number of staminate flowers than the pistillate flowers. This flowering behavior is not advantageous and economical, because it results in lower fruit set and yield, which is a common problem in bitter gourd cultivation. Androecy and gynoecy can usually be altered by environmental variables such as temperature, photoperiod, nutrition or by the application of plant growth regulators (Thomas, 2008) [14]. Landraces play an important role in breeding for developing high yielding and quality crop where fruit yield of the crop depends on the genetic potential of cultivars, (Dey *et al*., 2007) [5]. The adoption of new cultivar by farmer is usually rapid because no additional cost is involved and existing cropping systems and soil/water management practices are generally not affected. Several researchers evaluated the bitter gourd landraces across the diverse areas and create the opportunities for further development, and our attempts has been made for establishing relationship among the traits (Dey *et al*., 2006) [4]. Therefore, the present experiment was conducted to evaluate the performance of different physio-morphological attributes in relation to yield and nutritional status of bitter gourd accessions collected from different agro ecological zones of India.

Materials and Methods
The experiment was conducted at the vegetable research farm of the bihar agricultural university, Sabour, Bhagalpur and the soil of the experimental site was sandy loam with light texture having a pH of 6.5 to 7.0. The accessions collected were 21 bitter gourds namely Bitter Kathi, Line-114, Line-214, Line-314, BRBTL, Line-514, Line-814, Meghdoot, Preethi, Gangajalee Small, Jhalari, Indira, Pusa Aushadhi, Pirpaiti Local, Konkan Tara, Pusa Rasdar, BRBTW, Swarna Yamini, BRBTG, Leena, Pallee were used in this experiment. The N, P and K fertilizers were applied in the form of urea, diammonium phosphate and murate of potash, respectively. The experiment was laid out in RCBD with three replications. The data on morphological parameters like node no.to 1st staminate flower, node no. to 1st pistillate flower,

days to 1st staminate flower anthesis, days to 1st pistillate flower anthesis, days to 50% flowering, days to 1st fruit harvest, vine length(m), internodal length, number of fruits/ vine, fruit diameter (cm), fruit length (cm) , fruit weight, fruit yield/plant, were computed. Data were taken from five randomly selected plants. The biochemical and fruit quality attributes namely, vitamin c, acidity, total carotenoid, total chlorophyll, total sugar, total phenol, flavonoids, iron were computed following the standard methodologies (AOAC, 1980). Collected data were analyzed statistically using following the analysis of variance procedure (ANOVA), and Duncan's New Multiple Range Test (DMRT) comparison method (whenever applicable) at 5% level of significance ($P \leq 0.05$). Correlation matrix was performed between different traits.

Results

Morphological traits

The morphological traits were influenced by different landraces (Table. 1) *i.e.* node number to 1st staminate (9.41h), pistillate flower (10.21d) was observed early in Pusa Aushadhi. The days to 1st staminate flower anthesis (41.12g) and days to 1st pistillate flower anthesis (40.20g) was observed early in Pusa Aushadhi. The days to 50% flowering was observed highest in Preethi (54.17). Days to 1st Fruit harvest was observed early in Pusa Aushadhi (48.28 i). Vine Length was observed highest in bitter kathi (2.94a) whereas internodal length was observed highest in (line-214a).

Table 1: Mean table of Morphological traits using DMRT

S. No.	Genotype/Trait	Node no.to 1st staminate flower	Node No. to 1st Pistillate Flower	Days to 1st Staminate Flower Anthesis	Days to 1st Pistillate Flower Anthesis	Days to 50% Flowering	Days to 1st Fruit harvest	Vine Length(m)	Internodal Length
1.	Bitter Kathi	15.41(abc)	14.87(abc)	46.48(bcde)	47.60 (abcd)	51.72(abc)	52.35(fgh)	2.94(a)	8.17(abc)
2.	Line-114	13.91(cdef)	15.60(a)	43.97(defg)	46.74(bcde)	52.57(abc)	52.15(fgh)	1.90(ghi)	6.57(h)
3.	Line-214	12.55(fg)	15.40(ab)	43.40(efg)	44.86(de)	51.09(abcd)	51.99(gh)	2.33(de)	8.37(a)
4.	Line-314	15.23(abcd)	14.31(abc)	42.43(fg)	46.58(cde)	49.20(cd)	52.05(gh)	1.71(i)	8.17(abc)
5.	BRBTL	13.15(gh)	13.21(c)	44.68(cdef)	41.35(fg)	52.72(abc)	50.78(h)	2.61(bc)	4.75(k)
6.	Line-514	14.83(abcde)	15.73(a)	42.45(fg)	45.18(cde)	50.14(bcd)	54.47(e)	1.92(ghi)	7.92(abcde)
7.	Line-814	10.73(gh)	14.19(abc)	44.82(cdef)	46.55(cde)	50.00(bcd)	56.82(cd)	1.85(hi)	7.57(cdef)
8.	Meghdoot	13.60(cdef)	15.29(ab)	51.99(a)	47.30(bcd)	47.98(d)	58.53(bc)	2.03(gh)	8.09(abcd)
9.	Preethi	15.46(abc)	16.08(a)	47.58(bc)	47.55(abcd)	54.17(a)	55.44(de)	1.41(j)	8.21(ab)
10.	Gangajalee Small	16.24(a)	14.76(abc)	46.38(bcde)	49.87(ab)	52.16(abc)	55.49(de)	2.32(def)	7.39(ef)
11.	Jhalari	14.64(abcde)	15.58(a)	47.47(bc)	43.93(ef)	51.71(abc)	52.47(fgh)	2.14(efg)	7.61(bcdef)
12.	Indira	13.44(def)	13.55(bc)	49.18(ab)	46.89(bcde)	50.94(abcd)	51.36(h)	1.95(ghi)	8.25(a)
13.	Pusa Aushadhi	10.21(h)	9.41(d)	41.12(g)	40.20(g)	38.12(e)	48.28(i)	2.71(ab)	7.19(fg)
14.	Pirpaiti Local	14.32(bcdef)	13.08(c)	48.76(b)	48.29(abc)	51.25(abcd)	53.88(efg)	2.13(efgh)	7.37(ef)
15.	Konkan Tara	15.02(abcde)	14.95(abc)	46.79(bcd)	48.28(abc)	54.02(a)	54.02(ef)	1.89(ghi)	5.17(jk)
16.	Pusa Rasdar	14.56(abcde)	14.36(abc)	47.29(bc)	44.74(de)	51.09(abcd)	51.41(h)	1.32(j)	5.71(ij)
17.	BRBTW	15.13(abcd)	16.16(a)	48.03(b)	50.52(a)	51.65(abc)	59.63(ab)	2.05(fgh)	5.59(ij)
18.	Swarna Yamini	15.91(ab)	15.25(ab)	46.84(bcd)	46.76(bcde)	50.92(abcd)	61.28(a)	1.99(gh)	6.69(gh)
19.	BRBTG	14.40(abcdef)	15.49(ab)	47.57(bc)	46.12(cde)	52.81(ab)	53.67(efg)	2.38(cde)	6.17(hi)
20.	Leena	14.90(abcde)	15.29(ab)	48.81(b)	49.83(ab)	50.76(abcd)	53.86(efg)	2.49(bcd)	7.56(def)
21.	Pallee	15.00(abcde)	14.89(abc)	48.38(b)	46.75(bcde)	51.84(abc)	52.23(fgh)	2.33(de)	7.31(f)
Gen. Mean		14.22	14.64	46.40	46.47	50.80	53.91	2.11	7.13
C.V.		8.08	8.17	4.12	4.10	4.21	2.17	7.85	5.17
S.E.M.		0.66	0.69	1.10	1.10	1.23	0.67	0.11	0.21
C.D. 5%		1.90	1.97	3.16	3.15	3.53	1.93	0.27	0.61
C.D. 1%		2.54	2.64	4.23	4.21	4.72	2.58	0.37	0.81

Yield attributing traits

The highest number of fruits/vine was recorded in Konkan tara (41.46a-Table 2). It was observed that small and round fruit bearing genotypes produced maximum number of fruits per plant. This may be due to emergence of large number of primary and secondary branches in small round fruit bearing genotypes. The fruit length ranged from 7.12 to 20.24 and fruit diameter ranges from 6.83 to 12.30 where genotype Pallee observed highest fruit length (20.24a- Table 2) and fruit diameter (12.30b - Table 2). Fruit weight/plant of all genotype varied significantly from 27.98 to 144.45. BRBTL observed highest fruit weight/plant (144.45a- Table 2). The fruit yield/plant was observed highest in BRBTL (3.76a-Table 2).

Table 2: Mean table of Yield attributing traits using DMRT

S. No.	Genotype/Trait	Fruits/ Vine	Fruit Diameter (cm)	Fruit Length (cm)	Fruit Weight	Fruit yield/plant
1.	Bitter Kathi	36.75(cdefg)	9.29(cd)	13.73(def)	55.26(gh)	2.56(cd)
2.	Line-114	31.43(k)	7.65(fghi)	10.03(i)	43.05(kl)	1.71(gh)
3.	Line-214	38.75(abc)	7.75(fgh)	12.71(fgh)	53.64(ghi)	2.39(de)
4.	Line-314	22.77(l)	7.17(hi)	12.26(gh)	57.38(defgh)	1.70(gh)
5.	BRBTL	38.28(bcd)	14.50(a)	19.42(ab)	144.45(a)	3.76(a)
6.	Line-514	33.09(hijk)	8.23(efgh)	17.46(gh)	58.31(cdefg)	2.43(de)
7.	Line-814	37.46(cdef)	7.65(fghi)	12.34(h)	67.89(b)	3.20(b)
8.	Meghdoot	33.84(ghijk)	7.85(fgh)	12.02(d)	56.81(efgh)	2.42(de)
9.	Preethi	40.59(ab)	7.67(fghi)	14.56(j)	62.41(c)	3.22(b)
10.	Gangajalee Small	36.55(cdefg)	7.35(ghi)	7.46(a)	33.35(m)	1.64(h)
11.	Jhalari	37.77(bcde)	8.75(cde)	19.14(c)	44.99(kl)	2.09(efg)
12.	Indira	35.66(defgh)	6.83(i)	16.02(ac)	60.18(cdef)	2.56(cd)
13.	Pusa Aushadhi	35.75(defgh)	8.31(ef)	16.42(bc)	61.49(cde)	2.83(bc)
14.	Pirpaiti Local	32.35(ijk)	7.82(fgh)	13.32(efg)	41.86(l)	1.61(h)
15.	Konkan Tara	41.46(a)	8.45(def)	7.12(j)	27.98(n)	1.89(fgh)
16.	Pusa Rasdar	31.08(k)	9.46(c)	14.44(de)	50.27(ij)	1.96(fgh)
17.	BRBTW	34.70(fghij)	7.83(fgh)	16.33(bc)	52.80(hi)	2.27(def)
18.	Swarnayamini	35.65(defgh)	7.97(efgh)	19.02(a)	57.80(cdefg)	2.59(cd)
19.	BRBTG	36.99(cdef)	7.92(efgh)	19.42(a)	46.86(jk)	2.65(cd)
20.	Leena	35.13(efghi)	12.27(b)	19.74(a)	56.10(fgh)	2.48(cde)
21.	Pallee	31.79(jk)	12.30(b)	20.24(a)	61.84(cd)	2.52(cd)
Gen. Mean		35.14	8.72	14.91	56.89	2.40
C.V.		5.06	6.13	5.03	5.03	1.02
S.E.M.		1.03	0.31	0.43	1.65	5.50
C.D. 5%		2.93	0.80	1.24	1.47	1.58
C.D. 1%		3.92	1.81	1.66	6.32	2.12

Biochemical traits

Considerable variation was observed on different biochemical traits in different bitter gourd genotypes were presented in Table-3. The vitamin c was observed highest in BRBTL (463.75b). Acidity content was observed highest in Konkan tara (2.12a). Total carotenoid content was observed highest in Pusa Aushadhi (1241.1c). Total chlorophyll content was observed highest in Preethi (1.63a). Total sugar was observed highest in gangajalee small (0.96a). Total phenol was observed highest in BRBTW (9.17a). The flavonoids content was observed in swarnayamini (22.73a). The iron content was observed highest in BRBTW (0.92a).

Table 3: Mean table of biochemical traits using DMRT

S. No.	Genotype/Trait	Vitamin C	Acidity	Total carotenoid	Total Chlorophyll	Total Sugar	Total phenol	Flavonoids	Iron
1.	Bitter Kathi	84.00(d)	0.31(m)	345.4(o)	0.95(f)	0.22(m)	3.55(k)	21.68(b)	0.30(klm)
2.	Line-114	43.03(m)	0.65(h)	217.6(p)	0.90(fg)	0.37(df)	5.65(e)	19.75(d)	0.36(jk)
3.	Line-214	77.23(f)	0.96(e)	679.3(k)	0.54(kl)	0.29(jkl)	2.06(n)	11.97(l)	0.29(lm)
4.	Line-314	51.68(k)	0.23(n)	357.8(no)	1.09(e)	0.32(ghij)	2.48(m)	22.61(a)	0.42(hi)
5.	BRBTL	463.75(b)	0.42(j)	859.0(h)	0.83(gh)	0.48(b)	7.75(b)	16.64(f)	0.46(gh)
6.	Line-514	80.89(e)	1.25(b)	365.2(n)	1.20(d)	0.27(jkl)	1.68(o)	22.65(a)	0.27(lm)
7.	Line-814	54.58(j)	0.64(h)	463.7(m)	1.40(bc)	0.39(cde)	6.16(d)	10.76(m)	0.38(ij)
8.	Meghdoot	61.80(hi)	0.98(d)	149.3(q)	1.44(b)	0.30(ijkl)	2.24(n)	20.55(c)	0.64(c)
9.	Preethi	46.83(c)	0.94(f)	798.1(i)	1.63(a)	0.26(lm)	1.56(o)	12.52(k)	0.46(gh)
10.	Gangajalee Small	337.07(i)	0.65(h)	1368.5(b)	0.45(l)	0.96(a)	5.56(e)	13.89(i)	0.32(kl)
11.	Jhalari	59.53(i)	0.98(d)	742.1(j)	0.75(hi)	0.35(efgh)	1.31(p)	17.31(e)	0.36(j)
12.	Indira	62.67(h)	0.78(g)	795.4(i)	0.83(gh)	0.28(jkl)	2.16(n)	15.39(j)	0.78(k)
13.	Pusa Aushadhi	46.27(l)	1.13(c)	1241.1(c)	0.60(jk)	0.31(hijk)	6.57(c)	13.51(g)	0.64(bc)
14.	Pirpaiti Local	50.47(k)	0.23(n)	638.9(l)	0.65(ij)	0.22(m)	4.35(i)	8.67(o)	0.26(mb)
15.	Konkan Tara	640.21(a)	2.12(a)	1858.5(a)	1.33(c)	0.42(c)	5.17(f)	21.46(b)	0.78(d)
16.	Pusa Rasdar	77.67(f)	0.32(lm)	1154.2(d)	1.59(a)	0.42(c)	5.26(f)	14.63(h)	0.56(e)
17.	BRBTW	65.53(g)	0.44(j)	650.9(l)	1.13(de)	0.34(fghi)	9.17(a)	9.13(n)	0.92(a)
18.	Swarna Yamini	51.94(k)	0.36(k)	909.9(g)	0.50(kl)	0.36(defg)	3.07(l)	22.73(a)	0.48(fg)
19.	BRBTG	76.75(f)	0.56(i)	935.4(f)	0.65(ij)	0.30(ijkl)	4.55(h)	17.46(e)	0.52(ef)
20.	Leena	76.63(f)	0.24(n)	858.2(h)	1.17(de)	0.35(efgh)	4.97(g)	17.42(e)	0.49(fg)
21.	Pallee	76.00(f)	0.34(kl)	957.0(e)	1.55(a)	0.40(cd)	4.11(j)	17.56(e)	0.59(cd)
Gen. Mean		123.07	0.69	778.36	1.01	0.36	4.27	16.59	0.49
C.V.		1.15	1.78	1.48	6.07	7.16	2.62	1.15	7.23
S.E.M.		0.82	0.01	6.67	0.04	0.02	0.06	0.11	0.02
C.D. 5%		2.33	0.02	19.06	0.10	0.04	0.18	0.31	0.06
C.D. 1%		3.12	0.03	25.50	0.14	0.06	0.25	0.42	0.08

Correlation Matrix

Correlation matrix showed significant variation among the genotypes for both morphological and biochemical traits under study (Table 4). Correlation matrix brings genetic up gradation of character by selection, and have knowledge about character associations will surely help to identify the characters to make selection for higher yield with view to determine the extent and nature of relationship prevailing among yield attributing characters. An attempt has made to study the character association in the bitter gourd accessions (Khan *et al*., 2018) [13]. Correlation matrix showed significant correlation with most of the traits under study both at genotypic and phenotypic level. Phenotypic correlation matrix was higher than genotypic correlation matrix for all the traits under study. It was found highest for fruit yield/plant followed by other morphological and biochemical traits.

Table 4: Correlation Matrix of Morphological Traits

S. No.	Traits		Node number to 1st staminate flower	Node number to 1st pistillate flower	Days to 1st staminate flower anthesis	Days to 1st pistillate flower anthesis	Days to 1st fruit harvest	Vine length	Internodal length	Fruit Length
1.	Node number to 1st staminate flower	Rg	1.93							
		Rp	3.25							
2.	Node number to 1st pistillate flower	Rg		1.68						
		Rp		3.13						
3.	Days to 1st staminate flower anthesis	Rg			5.86					
		Rp			9.53					
4.	Days to 1st pistillate flower anthesis	Rg				5.23				
		Rp				8.87				
5.	Days to 1st fruit harvest	Rg					9.24			
		Rp					10.61			
6.	Vine length	Rg						0.15		
		Rp						0.18		
7.	Internodal length	Rg							1.14	
		Rp							1.28	
8.	Fruit Length	Rg								15.33
		Rp								15.89

S. No.	Traits		Fruit Diameter	No. of Fruits/ Vine	Fruit Weight	Fruit Yield/ Plant	Vitamin C	Acidity	Total carotenoid	Total chlorophyll	Total sugars	Total phenols	Flavonoids	Iron
9.	Fruit Diameter	Rg	3.69											
		Rp	3.98											
10.	No. of Fruits/ Vine	Rg		15.05										
		Rp		18.21										
11.	Fruit Weight	Rg			497.32									
		Rp			505.50									
12.	Fruit Yield/ Plant	Rg				292824.7								
		Rp				350794.5								
13.	Vitamin C	Rg					24812.1							
		Rp					24814.1							
14.	Acidity	Rg						0.2083						
		Rp						0.2085						
15.	Total carotenoid	Rg							167398.9					
		Rp							167532.4					
16.	Total chlorophyll	Rg								0.1440				
		Rp								0.1477				
17.	Total sugars	Rg									0.0230			
		Rp									0.0237			
18	Total phenols	Rg										4.6134		
		Rp										4.6259		
19.	Flavonoids	Rg											20.0490	
		Rp											20.0853	
20.	Iron	Rg												0.0331
		Rp												0.0343

Discussion

The bitter gourd is an unprivileged and under estimated vegetables due to its high medicinal and antinutrional properties (Peter and Abraham, 2007) [9]. Due to presence of diverse genotypes it can be cultivated in limited scale but their morpho-biochemical studies related to yield potential have not been explored comprehensively. The simultaneous appearance of staminate and pistillate flower the major initiation for achieving greater yield of this crop. The results indicated the appearance of pistillate flowers earlier than staminate one. Staminate flowers appeared on 10.41 node and continued acropetally whereas pistillate flowers initiated at

9th node. The appearance of pistillate flowers in basal node leads to the production of greater number of fruits. Islam *et al.*, 2014 and Rasul *et al*., 2004 [11] reported that node number to staminate flower varied considerably varied from 7 to 12th node whereas pistillate flower varied from 10 to 18th node which showed considerable variation among the genotypes.

Yield of any crop can be attributed through node number to 1st pistillate flowers, days to 1st pistillate flower anthesis, average fruit weight and number of fruit per plant. This yield attributes are influenced by morpho-physiological characters like vine length, internodal length, fruit length and fruit diameter. The finding is in agreement with Mia *et al*., 2012 [8] and Islam *et al*., 2009 [6]. The frequency of pistillate flowers was enhanced by endogenous hormone synthesis which contributed yield potential (Behera *et al*., 2009) [3]. But present results indicated that increased number of pistillate flowers might decreased the fruit size and reduce the yield. Our results showed fruit weight and number of fruit/plant is the direct indicator of yield enhancement. Therefore, major emphasis should be given on selection of genotypes having character of earliness and more number of fruits.

Phenotypic correlation matrix was higher than genotypic correlation matrix (Talukder *et al*., 2018) [13]. Correlation matrix was found highest for fruit yield/plant and lowest for node number to 1st pistillate flower days to 1st pistillate flower anthesis both at genotypic and phenotypic level whereas for biochemical traits it was found highest for total carotenoid content for both morphological and biochemical traits. Similar findings have been observed by Rani *et al*., 2014, Ray *et al*., 2017 and Yadagiri *et al*., 2017 [10, 12, 15]. Correlation co-efficient matrix for fruit yield/plant is the final character, which is complex chain of interrelating characters. Association of this yield-contributing character with yield and biochemical traits is important for making selection in the breeding program for yield, morphology and quality traits.

Conclusion

This studies concludes that there was significant amount of mean variation among the morphological and biochemical traits. Correlation matrix revealed that phenotypic correlation was higher than genotypic correlation. Correlation matrix exhibit significant positive correlation with fruit yield per plant. It was suggested that the environmental influence reduces the relationship between yield, total carotenoid, vitamin C and other yield contributing characters. This indicates that this character was the major contributor towards qualitative and quantitative traits. Therefore, maximum weight age should be given to this character for improvement of genotype for nutritional and productivity enhancement.

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