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Genetic variability and correlation studies in onion (*Allium cepa* L.) genotypes

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Abstract
Onion (*Allium cepa* L.) is one of the most valuable vegetable cum spice crop belongs to the family Alliaceae with chromosome number 2n=16. The existing knowledge about onion genetic diversity and resources is limited or one has to review periodically which helps in the efficient management of germplasm and selection of parents for crossing. Hence the present investigation was carried out with 40 onion genotypes for genetic variability which revealed that the 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 characters studied except for days to first flowering, days to 50 per cent flowering and TSS. Moderate to high heritability was observed for all characters and high genetic advance as per cent mean indicating that simple selection would be sufficient for these traits to bring genetic improvement. Individual bulb weight had positive and highly significant association with plant height, number of leaves, neck thickness and bulb diameter. Strong association of these traits revealed that selection based on these traits would ultimately improve the individual bulb weight per plant and it is also suggested that hybridization of genotypes possessing combination of such characters is most useful for obtaining desirable high yielding segregants.

Keywords: Hybridization, segregants, correlation, phenotypic, genotypic, correlation

Introduction
Onion is one of the most important spice and vegetable crop grown in India. The green leaves, immature and mature bulbs are used for vegetables and spice purposes. It is an important bulb crop throughout the world and is commercially cultivated in more than hundred countries. Onion is cultivated mainly as annual for bulb production and biennial for seed production. Onion has many medicinal values and used for preparation of various Homeopathic, Unani and Ayurvedic medicines. Onion consumption lowers the blood sugar (Augusti, 1990) [2]. Onion leaves and bulbs are nutritionally rich in minerals like calcium, potash and phosphorus (Ullah *et al*., 2005) [25]. Onion is characterized by its distinctive flavour and pungency which is the due to sulphur containing compounds (Allyl propyl disulphide) found in the scales of bulb. Highly pungent red coloured onions are preferred in India while less pungent yellow or white skinned ones are demanded in European and Japanese market.

Improvement in any crop depends on the magnitude of genetic variability and the extent of transmission of characters from one generation to the next. The yield and its component characters are polygenic in nature, hence influenced by the environmental factors. The knowledge of inter-relationships among the various components and their direct and indirect effect on yield are the important pre-requisites to bring genetic improvement in onion.

Genetic correlations between two characters arise because of linkage, pleiotropy or development induced functional relationship (Harland, 1936) [8]. Hence, correlation study has greater significance and could be effectively utilized in formulating an effective selection scheme. Many of these yield contributing characters are interact in desirable and undesirable direction. As such, it is necessary to estimate the correlation coefficients to aid in estimating the true association due to genetic cause.

Therefore, it is also essential to partition the overall variability into its heritable and non-heritable components, which will enhance the precision of selection. Thus, the present study was conceived with objective to examine the magnitude and the direction of variability, heritability, genetic advance, and correlation studies for yield components in 40 diverse genotypes of onion.

Materials and Methods

The present investigation was carried out at Kittur Rani Chennamma College of Horticulture Arabhavi, which falls under Northern Dry Zone of Karnataka. The experiment was conducted in black soil where, 40 germplasm accessions collected both by local farmer's field and some released varieties from public institution were raised in raised seed beds and transplanted in main fields during August 2016 to September 2016 and August 2017 to September 2017 in randomized block design with two replications consisting of one row of 15 plants for each entry. A spacing of 30 cm ×15 cm was followed and the crop was raised as per the recommended package of practices by UHS, Bagalkot.

The experiment was conducted for two consecutive years and observation recorded for each year were pooled and pooled data was used for analysis using INDOSTAT software. The observations recorded during the experiment are, plant height (in cm), neck thickness (in mm) and number leaves among the growth parameters, days to first and fifty per cent flowering and number of florets per plant among the flowering (earliness) parameters and bulb diameter/bulb equatorial diameter (in cm), bulb length/bulb polar diameter (in cm) and bulb shape index/P. E. (Polar: Equatorial) which was calculated by ratio between polar diameter and equatorial diameter of a bulb, bulb weight (g) and bulb yield per plot (Kg) among the bulb and yield parameters and among the quality parameters chlorophyll (mg/100mg of leaves) content and TSS (˚ brix) were recorded.

Results and discussions

Mean performance of genotypes

The mean performance and range of the 40 genotypes for all the thirteen characters are presented in the Table 1 and 2. The range in mean values, an indicator of variability revealed high variation for bulb yield per hectare, plant height at harvest, average bulb weight and bulb volume.

Growth parameters

In the present study low GCV and PCV were observed for plant height and neck thickness (Table 2). These, results are in agreement with Yaso (2007) [26] and Hosamani *et al.,* (2010) [10]. Narrow difference between GCV and PCV indicated that little environmental effect and may be governed by non-additive genes. However number of leaves showed high GCV and PCV and the results are in agreement with those of Yaso (2007) [26]. Hosamani *et al.,* (2010) [10] and Porta *et al.,* (2014) [17].

High heritability and GAM were observed for plant height (Table 2) where, the results are in line with the Trivedi *et al.,* (2006) [23], Gurjar and Singhania (2006) [7], Dhotre *et al.,* (2010) [5], Hosamani *et al.,* (2010) [10] and Ram *et al.,* (2011) [19]. The high heritability with high GAM estimates for this trait indicated the role of additive genes in governing its expression. Hence, selection on phenotype would be rewarding in improvement of this trait.

Among the growth parameters (plant height, number of leaves and neck thickness) significant association of individual bulb weight per plant was observed (Table 3 and 4). These results are in conformity with those of Mohammed *et al.,* (2000) [14], Rahman *et al.,* (2002) [18], Shrivastava *et al.,* (2004) [21], Meena *et al.,* (2007) [13] and Awale *et al.,* (2011) [3]. However results are in contrast with Morsy *et al.,* (2011) [15] and Dewangan and Sahu (2014) [4]. This may be because, since genetic potential of plant remain constant, when it contributes more to vegetative growth, indirectly it will help in absorbing more nutrients and translocation (increased transpiration due to increase in number of leaves) of photosynthesis to bulbs, yield will be increased. This also suggested that, yield might get reduced under lower transpiration rates (because lesser temperature in growing environment) though the leaf area. Therefore, it is logical that not to attempt for selecting genotypes performing well in vegetative growth, wherein which would simultaneously help in reduction in yield.

Earliness parameters

Days to first flowering and days to 50% flowering had low GCV, PCV and GAM but high heritability (Table 2). These results are in accordance with Yaso (2007) [26]. This indicated that simple selection for improvement of these traits may be helpful.

Bulb characters and yield parameters

Bulb diameter and bulb length had moderate GCV and PCV with high heritability and GAM (Table 2). These results are in line with Jansi and Thangaraj (2004) [12], Gowda *et al.,* (2004) [6]. However in contrast low GCV and PCV with low heritability and moderate GAM was observed for bulb shape index but narrow difference between GCV and PCV indicated that lesser environmental effect and may be governed by non-additive genes. This indicated that simple selection will be helpful in improvement of this trait.

High GCV, PCV, heritability and GAM was observed for individual bulb weight. This result is in accordance with Patil *et al.,* (2006) [16], Hayder *et al.,* (2007) [9], Hosamani *et al.,* (2010) [10], Singh *et al.,* (2010) [22], Ram *et al.,* (2011) [19] and Ibrahim *et al.,* (2013) [11]. This indicated presence of additive gene effect for individual bulb weight, 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.

Among the bulb characters, bulb shape index had significant positive association with the yield (Table 3 and 4). Applying selection pressure on this trait would be rewarding for improvement in the total yield. Similar results were reported by Saini *et al.,* (2014) [20], Porta *et al.,* (2014) [17] and Akter *et al.,* (2015) [1]. These results indicated that selection for longer bulb producing plants would simultaneously result in selection for higher total fruit yield.

Quality parameters

High estimates of GCV, PCV, heritability and GAM were observed for chlorophyll content. This result is compliance with earlier worker Trivedi *et al.,* (2006a) [24], Gurjar and Singhania (2006) [7], Yaso (2007) [26], Dhotre *et al.,* (2010) [5]. This suggested that simple selection might improve the trait.

TSS recorded low GCV and PCV, but high heritability and moderate GAM. This result was in line with values obtained by earlier worker Gurjar and Singhania (2006) [7], Yaso (2007) [26], Dhotre *et al.,* (2010) [5]. This suggests that preponderance of additive gene, so selection will be rewarding for improvement of this trait.

Table 1: Mean performance all 40 genotypes over 13 morphological parameters for diversity analysis

Genotype No.	Plant Height (cm)	No. of leaves	Neck thickness	Days to first flowering	Days to 50 % flowering	Number of florets plant	Bulb diameter	Bulb length	Bulb shape index	Individual weight (grams)	Bulb weight per plot (in Kg)	Chlorophyll content	TSS (in %)
1	39.1000	8.5000	10.1333	63.6667	85.6667	206.6667	5.2267	4.1167	0.8000	69.7367	41.1667	6.3800	11.3000
2	49.8000	9.0000	14.6167	58.5000	80.5000	424.3333	5.5000	4.9667	0.9433	75.3333	49.6667	23.5900	12.0833
3	58.3000	6.6667	15.7133	61.3333	83.3333	748.0000	2.9433	5.3667	1.8233	78.8533	53.6667	15.2800	14.2333
4	47.9000	9.5000	13.7900	52.5000	74.5000	470.6667	5.3667	5.1167	0.9533	61.5000	51.1667	11.3900	10.5833
5	36.0000	7.6667	12.7567	51.3333	73.3333	329.0000	3.5667	3.7167	1.0600	95.9467	37.1667	22.3867	12.2333
6	53.2000	8.5000	14.8000	51.6667	73.6667	311.5000	3.6833	5.9167	1.6867	158.7467	59.1667	18.8967	10.6000
7	39.1000	6.0000	12.3533	47.6667	69.6667	464.3333	4.3833	4.5167	1.0433	94.0067	45.1667	18.5567	11.4167
8	40.5000	9.0000	14.7800	54.3333	76.3333	363.3333	4.6333	4.6167	1.0200	91.9567	46.1667	16.7033	10.6000
9	46.2000	9.5000	18.2400	50.3333	72.3333	372.6667	4.1500	4.7833	1.2000	110.1800	47.8333	15.5367	10.1500
10	49.7000	8.3333	12.6700	50.6667	72.6667	175.6667	3.4900	4.9000	1.4133	120.9800	49.0000	21.0000	10.1500
11	37.4000	6.1667	10.6900	52.6667	74.6667	202.6667	3.8167	3.5333	0.9500	64.9633	35.3333	19.6467	10.7833
12	30.7000	5.1667	7.8933	56.1667	78.1667	129.6667	3.4433	3.0667	0.8967	59.6467	30.6667	23.4067	12.2333
13	55.6000	9.0000	18.0667	51.5000	73.5000	140.0000	3.2933	5.7167	1.7633	146.3333	57.1667	14.6933	10.5333
14	54.9000	8.3333	16.7267	54.6667	76.6667	172.1667	3.6500	5.6833	1.6100	131.0767	56.8333	20.4467	11.0500
15	47.3000	5.8333	11.1533	52.8333	74.8333	165.6667	4.2167	4.4167	1.0500	74.7433	44.1667	25.0067	10.6667
16	45.0000	9.0000	13.0467	49.3333	71.3333	177.1667	3.6667	4.4333	1.2900	98.9300	44.3333	23.5867	10.5333
17	38.0000	5.0000	14.9033	57.0000	79.0000	155.0000	4.5500	3.8667	0.9433	64.1467	38.6667	21.2600	10.5167
18	40.0000	7.1667	15.7400	56.3333	78.3333	149.1667	3.9167	3.9167	1.1133	81.2567	39.1667	24.9200	10.5333
19	42.5000	6.1667	14.5900	54.1667	76.1667	236.6667	5.7833	4.6167	0.7967	49.7833	46.1667	21.0733	10.9333
20	34.5000	8.3333	11.8967	48.3333	70.3333	404.5000	3.5000	3.5000	1.0300	72.9600	35.0000	25.6367	10.3667
21	45.4000	11.3333	16.6367	52.8333	74.8333	264.1667	4.7667	4.7333	1.0233	21.0000	47.3333	22.0200	10.1167
22	53.9000	8.1667	19.7467	58.0000	80.0000	361.1667	4.1833	5.4000	1.3400	124.2400	54.0000	24.2633	10.6833
23	57.4000	11.1667	15.7300	48.8333	70.8333	173.1667	3.6000	5.5000	1.5333	143.4200	55.0000	24.0300	10.7500
24	45.5000	5.3333	17.2500	52.8333	74.8333	166.6667	3.0500	4.9500	1.6000	150.0700	49.5000	22.4633	10.1333
25	47.1000	7.5000	15.8633	52.5000	74.5000	179.3333	3.7667	4.7333	1.2600	25.8333	47.3333	22.0667	10.5667
26	40.4000	6.8333	12.2900	58.1667	80.1667	170.8333	3.6500	4.0167	1.1133	86.4667	40.1667	22.5600	10.4000
27	33.5000	6.1667	10.7333	50.6667	72.6667	175.3333	3.5500	3.1667	0.8867	63.8233	31.6667	23.0767	10.5833
28	33.8000	8.6667	12.0800	49.3333	71.3333	154.0000	3.0167	3.4500	1.2500	100.0467	34.5000	21.7467	10.9667
29	37.7000	6.5000	14.0833	54.8333	76.8333	158.5000	3.5233	3.9500	1.2033	95.3300	39.5000	24.5700	11.4333
30	37.7000	6.1667	13.3733	56.0000	78.0000	184.3333	3.3467	4.2167	1.2633	101.2200	42.1667	24.2933	10.9333
31	41.8000	8.0000	16.1467	46.8333	68.8333	162.3333	4.0400	4.8333	1.2133	96.1267	48.3333	25.2700	10.5833
32	48.3000	5.3333	11.9833	50.3333	72.3333	157.3333	2.9967	5.3000	1.8900	163.7967	53.0000	24.7500	10.6267
33	44.6000	6.0000	13.9700	55.1667	77.1667	176.1667	3.4933	4.5833	1.5033	125.2033	45.8333	24.9033	11.6167
34	35.5000	7.3333	12.7100	56.1667	78.1667	179.1667	3.1800	3.4333	1.1633	91.6567	34.3333	24.8500	11.4833
35	42.5000	7.1667	10.8233	50.3333	72.3333	258.8333	2.7067	4.0333	1.4900	123.9367	40.3333	24.9067	11.4833
36	42.2000	7.1667	13.5133	48.5000	70.5000	164.8333	3.3767	5.1000	1.5467	129.7867	51.0000	23.6300	11.6167
37	36.3000	7.3333	12.3300	49.1667	71.1667	242.0000	3.0833	3.4667	1.1567	90.5567	34.6667	24.9300	12.6833
38	53.4000	9.8333	15.4867	51.0000	73.0000	346.6667	3.8733	5.4500	1.4700	122.2833	54.5000	24.3900	11.7167
39	40.9000	6.0000	11.6600	56.1667	78.1667	283.0000	2.9133	4.3667	1.5267	127.6033	43.6667	24.3600	12.1667
40	52.1000	11.3333	18.4033	52.6667	74.6667	490.0000	4.6167	5.1667	1.1700	107.0267	51.6667	15.6633	10.7833
Mean	43.8925	7.6542	13.9843	53.1333	75.1333	256.1667	3.8378	4.5154	1.2498	97.2627	45.1542	21.4535	11.0707
S.E.	3.1048	0.9380	1.2994	1.6402	1.8367	37.4547	0.2801	0.3788	0.1444	14.3250	3.7884	1.2402	0.2720
C.D. 5%	8.7380	2.6399	3.6571	4.6162	5.1693	105.4119	0.7883	1.0662	0.4065	40.3159	10.6621	3.4905	0.7654
C.D. 1%	11.5860	3.5003	4.8490	6.1207	6.8541	139.7686	1.0452	1.4137	0.5390	53.4560	14.1371	4.6281	1.0149
Range Lowest	30.7000	5.0000	7.8933	46.8333	68.8333	129.6667	2.7067	3.0667	0.7967	21.0000	30.6667	6.3800	10.1167
Range Highest	58.3000	11.3333	19.7467	63.6667	85.6667	748.0000	5.7833	5.9167	1.8900	163.7967	59.1667	25.6367	14.2333

Table 2: Different genetic parameters for quantitative and qualitative traits in onion germplasm

Sl. No.	Characters	Mean	Range	Genotypic variance	Phenotypic variance	Genotypic coefficient of variance (GCV in %)	Phenotypic coefficient of variance (PCV in %)	Heritability (h^2 in %)	Genetic Advance (GA) at 5%	Genetic Advance as per cent mean (GAM %) at 5%
1	Plant height (cm)	43.89	22.8-64	42.97	71.89	14.93	19.32	59.80	10.44	23.78
2	Number of leaves	7.65	3.50-13.00	1.96	4.60	18.29	28.02	42.60	1.88	24.59
3	Neck thickness (mm)	13.98	6.25-23.06	4.94	10.01	15.90	22.62	49.40	3.22	23.02
4	Days to first flowering	53.13	42.00-66.50	11.56	19.63	6.40	8.34	58.90	5.38	10.12
5	Days to 50 per cent flowering	75.13	64.00-89.50	10.88	21.00	4.39	6.10	51.80	4.89	6.51
6	Number of florets per plant	256.17	69.50-814.50	15870.85	20079.41	49.18	55.32	79.00	230.72	90.07
7	Bulb diameter (cm)	3.84	2.24-6.05	0.48	0.72	18.05	22.03	67.10	1.17	30.45
8	Bulb length (cm)	4.52	2.40-6.60	0.43	0.87	14.59	20.59	50.20	0.96	21.29
9	Bulb shape index	1.25	0.54-2.35	0.06	0.13	20.06	28.34	50.10	0.37	29.25
10	Individual bulb weight (g)	97.26	15.50-210.31	939.59	1555.21	31.52	40.55	60.40	49.08	50.46
11	Bulb weight per plot (Kg)	45.15	24.00-66.00	43.40	86.45	14.59	20.59	50.20	9.61	21.29
12	Chlorophyll content (mg/100g)	21.45	5.29-26.19	16.71	21.32	19.05	21.52	78.40	7.45	34.74
13	TSS (%)	11.07	9.65-15.05	0.62	0.84	7.11	8.28	73.60	1.39	12.56

Table 3: Phenotypic correlation coefficients among growth, earliness, yield and quality parameters in onion

Sl. No.	Characters	Plant height (cm)	Number of leaves	Neck thickness (mm)	Days to first flowering	Days to 50 per cent flowering	Number of florets per plant	Bulb diameter (cm)	Bulb length (cm)	Bulb shape index	Individual Bulb weight (g)	Bulb weight per plot (Kg)	Chlorophyll content (mg/100g)	TSS (%)
1	Plant height (cm)	1.00	0.33**	0.48**	0.04	0.02	0.24**	0.11	0.69**	0.43**	0.32**	0.69**	-0.13	0.03
2	Number of leaves		1.00	0.38**	-0.17	-0.15	0.26**	0.14	0.35**	0.12	0.11	0.35**	-0.21*	-0.16
3	Neck thickness (mm)			1.00	-0.01	0.00	0.21*	0.18*	0.5**	0.22*	0.16	0.5**	-0.11	-0.21*
4	Days to first flowering				1.00	0.98**	0.13	0.2*	-0.03	-0.12	-0.19*	-0.03	-0.26**	0.25**
5	Days to 50 per cent flowering					1.00	0.14	O.18	0.00	-0.09	-0.17	-0.03	-0.27**	0.25**
6	Number of florets per plant						1.00	0.18*	0.24**	0.05	-0.06	-0.24**	-0.35**	0.38**
7	Bulb diameter (cm)							1.00	0.11	-0.63**	-0.52**	0.11	-0.37**	-0.18
8	Bulb length (cm)								1.00	0.65**	0.55**	1**	-0.18*	-0.05
9	Bulb shape index									1.00	0.84**	0.65**	0.11	0.12
10	Individual Bulb weight (g)										1.00	0.55**	0.10	-0.01
11	Bulb weight per plot (Kg)											1.00	-0.19*	-0.05
12	Chlorophyll												1.00	0.03

	content (mg/100g)													
13	TSS (%)													1.00

Table 4: Genotypic correlation coefficients among growth, earliness, yield and quality parameters in onion

Sl. No.	Characters	Plant height (cm)	No.of leaves	Neck thickness (mm)	Days to first flowering	Days to 50 per cent flowering	Number of florets plant	Bulb diameter (cm)	Bulb length (cm)	Bulb shape index	Individual weight (g)	Bulb weight per plot (Kg)	Chorophyll content (mg/100g)	TSS (in %)
1	Plant height (cm)	1.00	0.59	0.82	0.06	0.08	0.41	0.08	0.94	0.78	0.50	0.94	-0.30	-0.06
2	Number of leaves		1.00	0.58	-0.23	-0.26	0.33	0.48	0.50	-0.10	-0.04	0.50	-0.41	-0.29
3	Neck thickness (mm)			1.00	0.01	0.00	0.28	0.22	0.85	0.45	0.29	0.85	-0.16	-0.29
4	Days to first flowering				1.00	1.00	0.17	0.29	-0.06	-0.20	-0.30	-0.06	-0.34	0.36
5	Days to 50 per cent flowering					1.00	0.16	0.32	-0.06	-0.22	-0.32	-0.06	-0.34	0.37
6	Number of florets per plant						1.00	0.30	0.33	-0.01	-0.14	0.33	-0.43	0.46
7	Bulb diameter (cm)							1.00	0.20	-0.66	-0.48	0.20	-0.50	-0.29
8	Bulb length (cm)								1.00	0.60	0.46	1.00	-0.33	-0.16
9	Bulb shape index									1.00	0.74	0.60	0.15	0.17
10	Individual Bulb weight (g)										1.00	0.46	0.13	-0.04
11	Bulb weight per plot (Kgs)											1.00	-0.33	-0.16
12	Chlorophyll content (mg/100g)												1.00	0.02
13	TSS (%)													1.00

Conclusion

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 characters studied except for days to first flowering, days to 50 per cent flowering and TSS. Moderate to high heritability was observed for all characters and high genetic advance as per cent mean indicating that simple selection would be sufficient for these traits to bring genetic improvement. Individual bulb weight had positive and highly significant association with plant height, number of leaves, neck thickness and bulb diameter. Strong association of these traits revealed that selection based on these traits would ultimately improve the individual bulb weight per plant and it is also suggested that hybridization of genotypes possessing combination of such characters is most useful for obtaining desirable high yielding segregants.

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