International Journal of Agriculture, Environment and Biotechnology
Citation: IJAEB: 8(4): 783-793 December 2015
DOI Number: 10.5958/2230-732X.2015.00087.X

Genetics and Plant Breeding

Genetic Analysis and Character Association in Different Genotypes of Onion (*Allium Cepa* L.)

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Paper No.: 371 Received: 12 Feb. 2015 Accepted: 10 Dec. 2015

Abstract

Analysis of variance revealed highly significant difference among the genotypes for all the characters studied which was highest for total bulb yield among all traits under study. High PCV and GCV higher were observed for B grade bulbs, unmarketable bulb yield (q ha^{-1}), marketable bulb yield (q ha^{-1}), total bulb yield and bulb yield plant^{-1}. High heritability supplemented with high genetic advance as a percentage of the mean was manifested by bulb yield plant^{-1} and total yield (q ha^{-1}). The association study resulted that the advantages of upgrading onion genotypes through simultaneous selection for equatorial diameter, followed by polar diameter, the number of leaves plant^{-1} at 90 DAT, neck thickness, plant height at 90 DAT and TSS. Path coefficient analysis revealed that polar diameter had highest positive direct effect followed by plant height at 60 DAT, TSS, plant height at 90 DAT, the number of leaves plant^{-1} at 90 DAT and polar: equatorial diameter were the most important traits contributing towards bulb yield plant^{-1}. Direct selection of equatorial diameter, neck thickness, days to maturity, the number of leaves plant^{-1} at 30 and 60 DAT and plant height at 30 DAT should be avoided instead of indirect selection. The highest production observed in genotype OSR-1344 and Agrifound Light Red. Low incidence percentage of stemphyliumblight was found in genotype ON14-06 incidence percentage of thrips was found in genotype ON14-15. Considerable variability was observed among the genotypes for foliage character, bulb shape, bulb colour and bolting tendency. Foliage color in green onion and shape and colour of onion bulb are most important characteristics to help customers in choosing cultivars in the market.

Highlights

- 31 diverse genotypes of onion were selected for the study of genetic variability, correlation and path analysis.
- Highest PCV and GCV was observed for B grade bulbs, unmarketable bulb yield (q ha^{-1}), marketable bulb yield (q ha^{-1}), total bulb yield and bulb yield plant^{-1}.
- The association estimated higher for equatorial diameter, and polar diameter had the highest positive direct effect.
- The highest production observed in OSR-1344 and Agrifound Light Red. Low incidence % of stemphylium blight was found in ON14-06 incidence %of thrips was in ON14-15.

Keywords: Onion, genetic variability, character association, path analysis, yield

Onion (*Allium cepa* L.) 2n=16 is an important bulb crop, belongs to the family Alliaceae and locally known as Pyaj. It is cultivated for food, medicines, religious purpose, spices and condiments since early times. Onion has strongly flavoured due to the presence of sulphur containing the compound in very small quantity (about

0.005%) in the form of volatile oil Allyl propyl disulphide ($C_6H_{12}O_2$) responsible for distinctive smell and pungency acts as gastric, stimulant and promotes digestion. Onion had many medicinal values and used for the preparation of various Homeopathic, Unani and Ayurvedic medicines. India ranks first in area and second in production. Maharashtra, Madhya Pradesh, Karnataka, Gujarat, Bihar, Andhra Pradesh, Rajasthan, Haryana and Tamil Nadu are the major onion growing states. The total area under production of onion in India during 2012-2013 was 1051.5 thousand ha with 16813.0 thousand MT production and 16.0 MT/ha productivity. However, in M.P. the total area was 111.73 thousand ha with total production 2691.00 thousand MT and productivity 24.1 MT/ha (NHB 2013).

The genetic variability and its components are the genetic fractions of observed variability that provides measures of transmissibility of the variation and response to selection. The knowledge of the pattern of inheritance of various characters are animportant consideration while, determining the most approximate breeding procedures applicable to any particular crop. The breeder's choice of the material for any improvement work consequently depends on the amount of genetic variability present. The phenotype is often not the true indicator of its genotype, due to the masking effect of the environment over genotype. Attempts have been made to determine the magnitude of heritable and non-heritable components and genetic parameters such as genotypic and phenotypic coefficient of variation, heritability and genetic advance as a percentage of mean in quantitative characters of onion. The previous workers who study the same objects i.e. Yaso (2007), Hosamani *et al.* (2010) and Adsul *et al.* (2010), Singh *et al.* (2010) and Jain *et al.* (2015). The estimates of correlation coefficient analysis are more useful in the estimation of inter-relationship among the yield contributing components. Estimation of path coefficient analysis gives the indication of the nature and extent of the direct and indirect effect on genotypes of their own yield contributing components. These corroborated the earlier study of Hosamani *et al.* (2010), Awale Degewione *et al.* (2011) for equatorial diameter, Awale Degewione *et al.* (2011), Saini *et al.* (2014) for polar diameter, Hosamani *et al.* (2010) , Saini *et al.* (2014) for neck thickness, Hayder *et al.* (2007), Awale Degewione*et al.* (2011), Saini *et al.* (2014) for plant height, Dhotre *et al.* (2010) for TSS. Hence, the present investigation would be carried out to generate information in respect of some genetic parameter related to fruit yield and its attributing traits and identify better-performing genotypes of onion in this location.

Material and Methods

The present investigation entitled "Studies on genetic analysis and character association in different genotypes of Onion (*Allium cepa* L.)" was conducted at Horticulture Complex, Department of Horticulture, College of Agriculture, J.N.K.V.V., Jabalpur (M.P.) during *Rabi* season2014-2015. The experimental materials for the present investigation were comprised of 31 genotypes of onion were transplant on plot size 3.0 × 2.0 m in Randomized Complete Block Design with three replications, to estimate the genetic variability, association and path analysis. The row and plant spacing were maintained at 15 × 10 cm., observations were recorded by five random competitive plants selected from each genotype separately for quantitative, and qualitative parameters were evaluated as per standard procedure. The main objectives were in investigation estimate the genetic variability, correlation and path coefficients analysis between yield and its attributing characters to identify better performing genotypes in onion.

Statistical analysis: The data based on the mean of individual plants selected for observation were statistically analyzed described by Panse and Sukhatme (1967) to find out overall total variability present in the material under study for each character and all the populations. PCV and GCV were calculated by using the formula is given by Burton (1952) and estimates of PCV and GCV according to Sivasubramanian S. and Madhava Menon (1973) *viz.,* Low (0-10%), Moderate (10-20%), High (20% & >). Estimation of heritability was done as per the formula given by Hanson *et al.* (1956) and Genetic Advance wascalculated by using the method suggested by Johnson *et al.* (1955) and also categorized into low moderate and high as follows; Low (0-10%), Moderate (10-20%), High (20% & >).

The correlation coefficients were calculated in all possible combinations taking all the characters into consideration at genotypic, phenotypic and environmental levels by using the formula as proposed by Miller *et al.* (1958) and the phenotypic correlations were tested for their significance by using "t" test. Path coefficient analysis was worked out to show the cause and effect relationship between yield and various yield components and to partition the total correlation coefficient into direct and indirect effects. This procedure was developed by Wright (1921) and as per consent used by Li (1956) and followed by Dewey and Lu (1959).Path coefficient were to be rated based on the scales given below; > 1.0 = Very High, 0.30 – 0.99 = High, 0.2 – 0.29 = Moderate, 0.1 – 0.19 = Low.

Result and Discussion

Analysis of variance: The main objective of the present investigation was to study the diversity present in thirty-one genotypes of onion. The estimates of amean sum of square due to genotypes were highly significant for all the characters, indicating the presence of genetic diversity in the existing material. Yaso (2007), Hosamani *et al.* (2010) and Adsul *et al.* (2010), also reported the high estimates of variability for selection of important genotypes to achieve the good breeding material.

Genetic variability

Mean performance of the genotypes: The mean performance of the genotypes (Table: 1 and Plate 1: Showing genotypes variability in shape and color of theonion bulb.) revealed a wide range of variability for all the traits. The variation was the highest for total bulb yield q ha^{-1} (112.88 to 351.92) followed by marketable yield q ha^{-1} (98.44-323.42 q ha^{-1}), incidence percentage of stemphyllium blight (7.33- 47.00), bulb yield plant^{-1} (17.0-53.0 g), incidence percentage of thrips (16.33-51.13), unmarketable yield q ha^{-1} (12.63-35.31 q ha^{-1}), C grade bulbs (74.10-90.83 %), plant height at 90 DAT (40.73 to 56.53 cm), plant height at 60 DAT (40.6-54.47 cm), B grade bulbs (5.07-16.32 %), days to maturity (130.0-141.0 days), bolter bulbs (0-7.64 %), plant height at 30 DAT (20.47-27.73 cm), double bulbs (0.13-7.39 %), A grade bulbs (4.09-10.22 %), number of leaves plant^{-1} at 90 DAT (9.60-15.27), total soluble solid (8.63-11.83%), polar diameter (3.34-4.98 cm), equatorial diameter (3.19-4.67 cm), number of leaves plant^{-1} at 60 DAT (4.13- 5.60), number of leaves plant^{-1} at 30 DAT (3.87- 5), neck thickness (0.61-1.05 cm) and polar: equatorial of bulb (0.92-1.19). The findings were quite similar to as reported by Yaso (2007), Mallor *et al.* (2011a), Mallor *et al.* (2011b), Rashid *et al.* (2012), Panse *et al.* (2013) in garlic, Esho*et al.* (2015) in garlic and Jain *et al.* (2015).

Coefficient of variation

In the present findings, PCV were observed to be higher than the corresponding GCV for all the characters studied (Table 1). However the differences was narrow which implied their relative resistance to environmental variation. It also described that genetic factors were predominantly responsible for expression of those attributes and selection could be made effectively by phenotypic performance. The finding of Yaso (2007), Singh *et al.* (2010) and Jain *et al.* (2015)are also corroboratedwith the present findings.

The phenotypic coefficient of variations: The phenotypic coefficient of variation (Table 1) ranged from

Table 1: Showing genetic variability, heritability and genetic advance in onion

	Characters		Grand Mean	Range		CV		Heritability % (bs)	GA	GA as % of mean
				Min.	Max.	PCV	GCV			
X_1	Plant height (cm)	30 DAT	24.32	20.47	27.73	10.24	5.75	31.49	1.62	6.64
		60 DAT	46.86	40.60	54.47	10.07	5.56	30.45	2.96	6.32
		90 DAT	48.99	40.73	56.53	8.68	5.83	45.08	3.95	8.06
X_2	Number of leaves plant^{-1}	30 DAT	4.30	3.87	5.00	7.19	5.97	68.91	0.44	10.21
		60 DAT	4.81	4.13	5.60	8.51	6.88	65.46	0.55	11.46
		90 DAT	12.65	9.60	15.27	13.57	12.05	78.77	2.79	22.03
X_3	Polar diameter (cm)		4.18	3.34	4.98	10.51	9.59	83.23	0.75	18.01
X_4	Equatorial diameter (cm)		4.12	3.19	4.67	9.80	9.26	89.22	0.74	18.00
X_5	Polar equatorial		1.02	0.92	1.19	7.54	4.78	40.10	0.06	6.22
X_6	Neck thickness (cm)		0.82	0.61	1.05	16.31	13.79	71.54	0.20	23.91
X_7	A grade bulb (%)		6.38	4.09	10.22	35.12	23.78	45.84	2.12	33.18
X_8	B grade bulb (%)		10.49	5.07	16.32	38.78	25.36	42.78	3.58	34.17
X_9	C grade bulb (%)		83.13	74.10	90.83	6.47	4.24	42.92	4.76	5.72
X_{10}	Marketable bulb yield (q ha^{-1})		200.48	98.44	323.42	27.96	23.20	68.80	79.46	39.63
X_{11}	Unmarketable bulb yield (q ha^{-1})		22.99	12.63	35.31	38.63	20.28	27.57	5.04	21.94
X_{12}	Total bulb yield (q ha^{-1})		223.48	112.88	351.92	26.41	22.57	73.08	88.84	39.75
X_{13}	TSS (Brix)		10.45	8.63	11.83	7.99	6.95	75.70	1.30	12.46
X_{14}	Days to maturity		135.0	130.0	141.0	2.61	2.57	96.69	7.03	5.21
X_{15}	Bulb yield plant^{-1}		33.66	17.0	53.0	26.41	22.57	73.08	13.38	39.75

Table 2: Estimates of genotypic and phenotypic correlation coefficients among yield and its contributing traits in onion

	Characters		Plant height (cm) 60DAT X_1	Plant height (cm) 90DAT X_2	Leaves plant at 30 DAT X_3	Leaves plant at 60 DAT X_4	Leaves plant^{-1} at 90 DAT X_5	Polar diameter (cm) X_6	Equatorial diameter (cm) X_7	Polar: Equato-rial X_8	Neck thick-ness (cm) X_9	TSS (Brix) X_{10}	Days to maturity X_{11}	Bulb yield plant-^{1} X_{12}
X_1	Plant height (cm) 30DAT	G	0.644	0.012	0.668	0.693	0.249	-0.198	0.048	-0.509	0.220	0.264	0.241	-0.041
		P	0.710**	0.089	0.278**	0.320**	0.124	-0.057	-0.011	-0.080	0.150	0.085	0.143	-0.072
X_2	Plant height (cm) 60DAT	G	1	0.652	0.771	0.624	0.556	0.214	0.571	-0.770	0.670	-0.136	0.180	0.304
		P	1	0.385**	0.408**	0.512**	0.271**	0.150	0.265*	-0.129	0.324**	-0.062	0.080	-0.015
X_3	Plant height (cm) 90DAT	G		1	0.750	0.706	0.522	0.748	0.804	-0.096	0.952	-0.376	0.085	0.575
		P		1	0.329**	0.442**	0.374**	0.482**	0.535**	-0.016	0.504**	-0.157	0.080	0.270**
X_4	Leaves plant^{-1} at 30 DAT	G			1	0.901	0.270	0.012	0.303	-0.601	0.466	-0.187	-0.082	0.147
		P			1	0.657**	0.178	-0.027	0.237*	-0.363**	0.419**	-0.102	-0.056	0.127
X_5	Leaves plant^{-1} at 60 DAT	G				1	0.108	0.075	0.224	-0.279	0.621	-0.341	-0.104	0.014
		P				1	0.107	0.080	0.195	-0.163	0.455**	-0.228*	-0.089	-0.012
X_6	Leaves plant^{-1} at 90 DAT	G					1	0.672	0.744	-0.112	0.476	0.119	0.249	0.799
		P					1	0.539**	0.635**	-0.094	0.349**	0.072	0.209*	0.607**
X_7	Polar diameter (cm)	G						1	0.896	0.396	0.600	-0.049	0.390	0.844
		P						1	0.750**	0.308**	0.504**	-0.061	0.353**	0.651**
X_8	Equatorial diameter (cm)	G							1	-0.248	0.710	-0.013	0.272	0.875
		P							1	-0.167	0.534**	-0.007	0.264*	0.689**
X_9	Polar: Equatorial diameter (cm)	G								1	-0.149	-0.093	0.288	0.103
		P								1	-0.046	-0.052	0.164	-0.120
X_{10}	Neck thickness (cm)	G									1	-0.112	-0.084	0.597
		P									1	-0.043	-0.060	0.405**
X_{11}	TSS (Brix)	G										1	-0.073	0.341
		P										1	-0.061	0.244*
X_{12}	Days to maturity	G											1	0.207

Significant at 5% level = * Significant at 1% level = *

Table 3: Path coefficients showing direct and indirect effects of different characters on bulb yield per plant (g) in Onion

Characters		Plant height (cm) 30DAT	Plant height (cm) 60DAT	Plant height (cm) 90DAT	Leaves /plant at 30 DAT	Leaves /plant at 60 DAT	Leaves /plant at 90 DAT	Polar diameter (cm)	Equatorial diameter (cm)	Polar: Equatorial	Neck thickness (cm)	TSS (Brix)	Days to maturity	Bulb yield plant^{-1}
Plant height (cm) 30DAT	G	**-0.043**	0.416	0.003	-0.051	-0.033	0.008	-0.256	-0.019	-0.004	-0.104	0.126	-0.083	-0.041
	P	0.101	-0.212	-0.008	0.043	-0.020	0.028	-0.033	-0.002	0.017	0.003	0.018	-0.008	-0.072
Plant height (cm) 60DAT	G	-0.028	**0.646**	0.157	-0.059	-0.030	0.017	0.277	-0.225	-0.006	-0.318	-0.065	-0.062	0.304
	P	0.072	-0.298	-0.033	0.064	-0.032	0.062	0.088	0.047	0.028	0.006	-0.013	-0.005	-0.015
Plant height (cm) 90DAT	G	-0.001	0.421	**0.241**	-0.058	-0.034	0.016	0.967	-0.317	-0.001	-0.452	-0.179	-0.029	0.575
	P	0.009	-0.115	-0.085	0.051	-0.028	0.085	0.282	0.095	0.003	0.010	-0.033	-0.005	0.270**
Leaves plant^{-1} at 30	G	-0.029	0.498	0.180	**-0.077**	-0.043	0.008	0.016	-0.120	-0.005	-0.221	-0.089	0.028	0.147
DAT	P	0.028	-0.122	-0.028	0.156	-0.041	0.041	-0.016	0.042	0.077	0.008	-0.022	0.003	0.127
Leaves plant^{-1}at 60 DAT	G	-0.030	0.403	0.170	-0.069	**-0.048**	0.003	0.097	-0.088	-0.002	-0.295	-0.163	0.036	0.014
	P	0.032	-0.153	-0.038	0.102	-0.062	0.024	0.047	0.034	0.035	0.009	-0.048	0.005	-0.012
Leaves plant^{-1}at 90 DAT	G	-0.011	0.359	0.126	-0.021	-0.005	**0.031**	0.869	-0.293	-0.001	-0.226	0.057	-0.085	0.799
	P	0.013	-0.081	-0.032	0.028	-0.007	0.228	0.316	0.112	0.020	0.007	0.015	-0.012	0.607**
Polar diameter (cm)	G	0.009	0.138	0.180	-0.001	-0.004	0.021	**1.293**	-0.353	0.003	-0.285	-0.023	-0.134	0.844
	P	-0.006	-0.045	-0.041	-0.004	-0.005	0.123	0.585	0.132	-0.066	0.010	-0.013	-0.020	0.651**
Equatorial diameter (cm)	G	-0.002	0.369	0.193	-0.023	-0.011	0.023	1.159	**-0.394**	-0.002	-0.337	-0.006	-0.093	0.875
	P	-0.001	-0.079	-0.046	0.037	-0.012	0.145	0.439	0.177	0.036	0.010	-0.001	-0.015	0.689**
Polar: Equatorial dia	G	0.022	-0.498	-0.023	0.046	0.013	-0.003	0.512	0.098	**0.008**	0.071	-0.044	-0.099	0.103
	P	-0.008	0.038	0.001	-0.057	0.010	-0.021	0.180	-0.030	-0.213	-0.001	-0.011	-0.009	-0.120
Neck thickness (cm)	G	-0.010	0.433	0.229	-0.036	-0.030	0.015	0.776	-0.280	-0.001	**-0.474**	-0.053	0.029	0.597
	P	0.015	-0.097	-0.043	0.065	-0.028	0.080	0.295	0.094	0.010	0.019	-0.009	0.003	0.405**
TSS (Brix)	G	-0.011	-0.088	-0.090	0.014	0.016	0.004	-0.063	0.005	-0.001	0.053	**0.477**	0.025	0.341
	P	0.009	0.018	0.013	-0.016	0.014	0.016	-0.036	-0.001	0.011	-0.001	0.212	0.004	0.244*
Days to maturity	G	-0.010	0.116	0.020	0.006	0.005	0.008	0.504	-0.107	0.002	0.040	-0.035	**-0.343**	0.207

Residual effect Genotypic = 0.0954 and Phenotypic = 0.2888

2.61% for days to maturity to 38.78% for B grade bulbs. The phenotypic coefficient of variations was high for characters viz., B grade bulbs, unmarketable bulb yield (q ha^{-1}), marketable bulb yield (q ha^{-1}), total bulb yield (q ha^{-1}) and bulb yield $plant^{-1}$. The findings are in close harmony with the result of Ananthan and Balakrishnamoorthy (2007), Hayder *et al.* (2007), Esho*et al.* (2015) in Garlic and Jain *et al.* (2015) for bulb yield $plant^{-1}$. Singh *et al.* (2010) for marketable bulb yield q ha^{-1}. Hayder *et al.* (2007), Singh *et al.* (2010) for total bulb yield q ha^{-1} and Mallor *et al.* (2011b).

However, it was exhibited moderate for characters like neck thickness, thenumber of leaves $plant^{-1}$ at 90 days, polar diameter, plant height at 30 DAT and plant height at 60 DAT. The findings are similar to that of the present findings Singh *et al.* (2010), Hosamani *et al.* (2010) for a number of leaves $plant^{-1}$. It was exhibited low for characters *viz.,* days to maturity, C grade bulbs, Number of leaves $plant^{-1}$ at 30 DAT, polar: equatorial, TSS, thenumber of leaves $plant^{-1}$ 60 DAT, plant height at 90 DAT and equatorial diameter. The finding of Morsy *et al.* (2011) for days to maturity, Singh *et al.* (2010), Hosamani *et al.* (2010) for number of leaves $plant^{-1}$, Singh *et al.* (2010) for TSSwere similar to the present finding which indicated that there is limited scope for improvement.

The genotypic Coefficient of variation: It is revealed from the genotypic coefficient of variation (Table 1) varied from 2.57 % for days to maturity to B grade bulbs (25.36%). The high genotypic coefficient of variation was observed for B grade bulbs, A grade bulbs, marketable yield (q ha^{-1}), total yield (q ha^{-1}), bulb yield $plant^{-1}$, and unmarketable yield (q ha^{-1}). The findings are in close harmony with the result of Singh *et al.* (2010) for marketable bulb yield (q ha^{-1}), Hayder *et al.* (2007), Singh *et al.* (2010) for total bulb yield (q ha^{-1}), Ananthan and Balakrishnamoorthy (2007), Hayder *et al.* (2007), Dhall *et al.* (2013)and Jain *et al.* (2015) for bulb yield $plant^{-1}$. It was moderate for the characters such as neck thickness

Table 4: Categorization of onion genotypes based on foliage character

Waxy	ON14-01, ON14-04, ON14-06, ON14-15, ON14-25, OSR-1344, OSR-1347, OSR-1359, OSR-1362, OSR-1364, ASRO 1201, ASRO 1203, ASRO 1207, ASRO 1227, ASRO 1229, ASRO 1275
Glossy	ON14-09, ON14-11, ON14-17, ON14-27, OSR-1323, OSR-1349, OSR-1352, OSR-1357, OSR-1354, ASRO 1215, ASRO 1236, ASRO 1238, ASRO 1271, ASRO 1273, ALR

Table 5: Categorization of onion genotypes based on bulb colour

Dark red	ON14-01, ON14-04, ON14-15, OSR-1344, OSR-1349, OSR-1352 ASRO 1271
Red	OSR-1354, OSR-1359, OSR-1364, ASRO 1229
Light red	ON14-06, ON14-09, ON14-11, ON14-17, ON14-25, ON14-27, OSR-1323, OSR-1357, OSR-1362, ASRO 1201, ASRO 1203, ASRO 1207, ASRO 1227, ASRO 1273, ASRO 1275, ALR
Yellow	OSR-1347
White	ASRO 1215, ASRO 1236, ARSO 1238

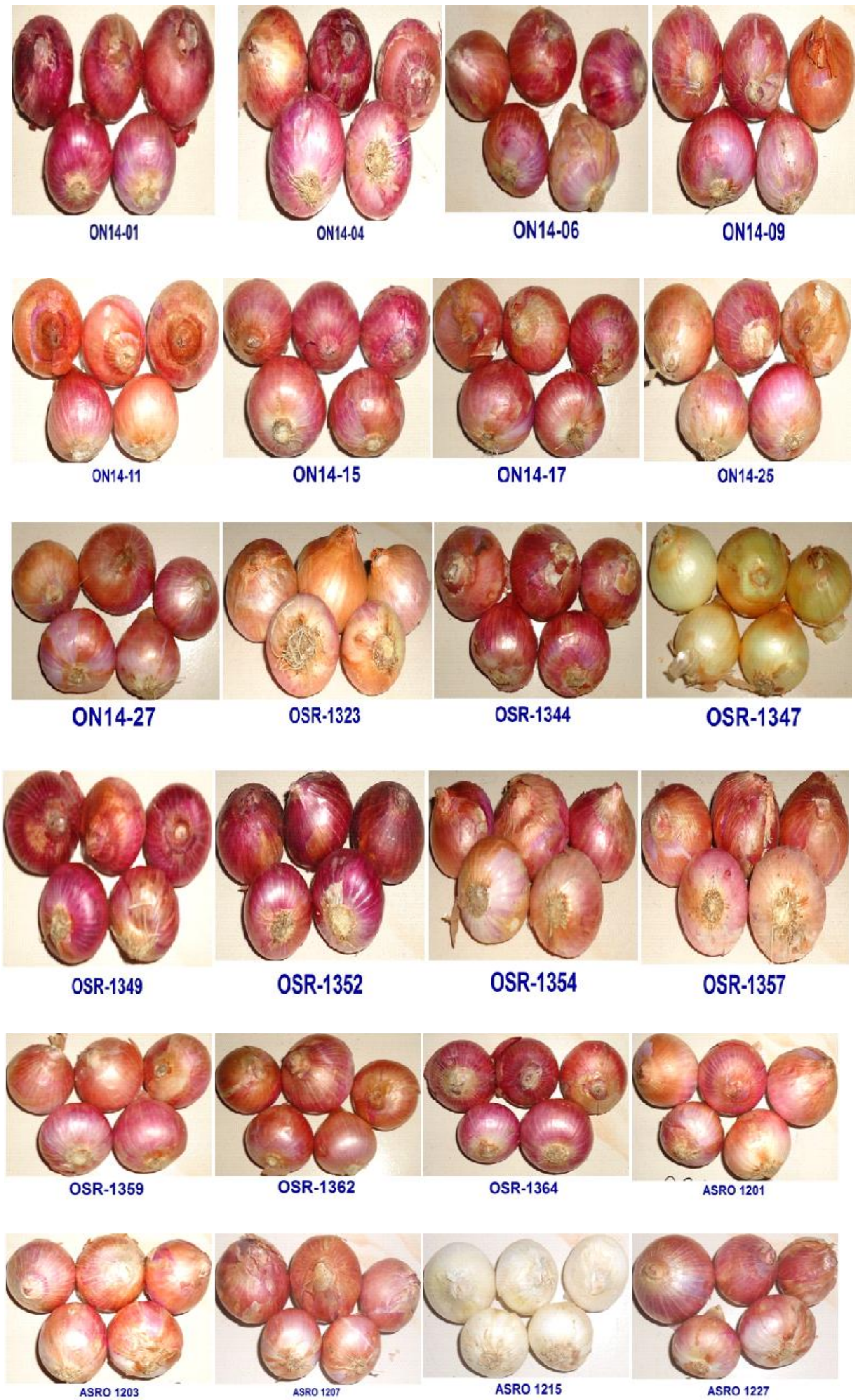
Table 6: Categorization of onion genotypes based on bulb shape

Flat	ON14-01, ON14-09, ON14-15, OSR-1349, OSR-1354, ASRO 1203, ASRO 1207, ASRO 1215, ASRO 1271, ASRO 1275, ALR
Oval	ON14-06, ON14-11, ON14-25, OSR-1347, OSR-1352, OSR-1357, OSR-1359, OSR-1362, ASRO 1201, ASRO 1227, ASRO 1236, ASRO 1273
Round	ON14-04, ON14-17, ON14-27, OSR-1323, OSR-1344, OSR-1364, ASRO 1229, ASRO 1238

Table 7: Categorization of onion genotypes based on bolting tendency

Absent	ON14-06, ON14-17, OSR-1344, OSR-1347, OSR-1352, OSR-1362 OSR-1364, ASRO 1203, ASRO 1207, ASRO 1227, ASRO 1229, ASRO 1238, ASRO 1273, ASRO 1275,ALR
Weak	ON14-01, ON14-04, ON14-11, ON14-15, ON14-25, ON14-27, OSR-1323, OSR-1349, OSR-1354, OSR-1357, OSR-1359, ASRO 1201, ASRO 1236, ASRO 1271
Medium	ON14-09
Strong	ASRO 1215

Plate 1: genotypes showing variability in shape and color of onion bulb



and number of leaves plant^{-1} at 90 DAT. While, days to maturity, C grade bulbs, polar: equatorial, plant height at 60 DAT, plant height at 30 DAT, plant height at 90 DAT, number of leaves plant^{-1} at 30 DAT, number of leaves plant^{-1} at 60 DAT, TSS, equatorial diameter and polar diameter showed low genotypic coefficient of variation.The finding of Morsy *et al.* (2011) for days to maturity, Singh *et al.* (2010), Hosamani *et al.* (2010) for number of leaves plant^{-1}, Singh *et al.* (2010) for TSS Duggi *et al.*(2013) in okrawere similar to the present finding which indicated that there is limited scope for improvement.

Heritability and Genetic Advance: The heritability estimate was observed very high for days to maturity (Table 1). However, high estimates of heritability were obtained for the traits like equatorial diameter followed by polar diameter, number of leaves plant^{-1} at 90 DAT, TSS, total yield (q ha^{-1}), bulb yield plant^{-1} and neck thickness, indicated that the high values of heritability for these characters expressed that they were least influenced by environmental modification. It reflected that the phenotypes were the true representative of their genotypes and selection based on phenotypic performance would be reliable. The results were in close proximate to that of Hosamani *et al.* (2010), Singh *et al.* (2010), Ibrahim *et al.* (2013) for a number of leaves plant^{-1}, Hosamani *et al.* (2010), Singh *et al.* (2010) for neck thickness. However, it was recorded moderate for a number of leaves plant^{-1} at 30 DAT, marketable yield (q ha^{-1}) and the number of leaves plant^{-1} at 60 DAT. The findings were in agreement to Hayder *et al.* (2007), Dhall *et al.* (2013), Duggi *et al.*(2013) in okraIbrahim *et al.* (2013) for number of leaves plant^{-1}, Yaso (2007), Singh *et al.* (2010) for marketable yield q ha^{-1}. Whereas, low estimates of heritability were recorded for unmarketable yield (q ha^{-1}), plant height at 60 DAT, plant height at 30 DAT, polar: equatorial, B grade bulbs, C grade bulbs, plant height at 90 DAT and A grade bulbs. The results were in close proximate to that of Ibrahim *et al.* (2013) for plant height.

The highest estimate of genetic advance as a percentage of the mean was recorded for both bulb yield plant^{-1} and total bulb yield (q ha^{-1}), followed by marketable yield (q ha^{-1}), B grade bulbs and A grade bulbs. The results were in consonance with Dhotre *et al.* (2010) and Ibrahim *et al.* (2013) for bulb yield plant^{-1}, Melke and Ravishankar (2006), Yaso (2007), Hayder *et al.* (2007), Hosamani *et al.* (2010), Singh *et al.* (2010) for total bulb yield q ha^{-1}, Yaso (2007), Singh *et al.* (2010) for marketable yield q ha^{-1}. Neck thickness, the number of leaves plant^{-1} at 90 DAT and unmarketable yield (q ha^{-1}), polar diameter and equatorial diameter showed the moderate value of genetic advance as a percentage of the mean. The findings were in agreement to the findings of Hosamani *et al.* (2010) for neck thickness, Hayder *et al.* (2007) for a number of leaves plant^{-1}. Whereas, low estimates were observed for rest of characters.

High heritability coupled with high genetic advance for traits like bulb yield plant^{-1} and total yield q ha^{-1}, suggested that the preponderance of additive genes. It also indicated higher response for selection of high yielding genotypes as these characters are governed by additive gene actions. The results agreed with Jain *et al.* (2015) for bulb yield plant^{-1}.High heritability supplemented with moderate genetic advances as a percentage of the mean were manifested by neck thickness, a number of leaves plant^{-1} at 90 DAT, polar diameter, equatorial diameter, which might be attributed to additive gene action conditioning their expression and phenotypic selection for their amenability can be brought about.

Correlation coefficient analysis

The magnitude of genotypic correlation was higher than the phenotypic correlation for all the traits that indicated an inherent association between various characters (Table 2). The findings were in agreement to Hosamani *et al.* (2010). Bulb yield plant^{-1} was recorded highly significant and positive correlation with equatorial diameter, followed by polar diameter, the number of leaves plant^{-1} at 90 DAT, neck thickness, plant height at 90 DAT and TSS indicating that these characters are the primary yield determinants in onion and can be improved through direct selection. These findings corroborated the earlier findings of Hosamani *et al.* (2010), Dhotre *et al.* (2010), Awale Degewione *et al.* (2011), Saini *et al.* (2014) for equatorial diameter, Awale Degewione*et al.* (2011), Saini *et al.* (2014) for polar diameter, Hosamani *et al.* (2010), Dhotre *et al.* (2010), Saini *et al.* (2014) for neck thickness, Hayder *et al.* (2007), Awale Degewione *et al.* (2011), Saini *et al.*(2014) for plant height, Dhotre *et al.* (2010) for TSS and Panigrahi *et al.* (2013) in Potato.

Plant height at 30 DAT showed significantly and positive correlation with plant height at 60 DAT, the number of leaves plant^{-1} at 60 DAT, and the number of leaves plant^{-1} at 30 DAT. Plant height at 60 DAT showed highly significant and positive with a number of leaves plant^{-1} at 60 DAT, the number of leaves plant^{-1} at 30 DAT, plant height at 90 DAT, neck thickness, the number of leaves plant^{-1} at 90 DAT and equatorial diameter. Plant height at 90 DAT expressed a highly significant and positive correlation coefficient with equatorial diameter, neck thickness, polar diameter, the number of leaves plant^{-1} at 60 DAT, the number of leaves plant^{-1} at 90 DAT, the number of leaves plant^{-1} at 30 DAT and bulb yield plant^{-1}. These findings corroborated the earlier findings of Awale Degewione *et al.* (2011), Saini *et al.* (2014) bulb yield plant^{-1}.A number of leaves plant^{-1} at 30 DAT expressed significantly and positive correlation with the number of leaves plant^{-1} at 60 DAT, neck thickness and equatorial diameter while, it was found significant and negative correlation with polar: equatorial. A number of leaves plant^{-1} at 60 DAT expressed significantly and positively associated with neck thickness, while, it was foundsignificant and negative association with TSS. Finding closely related with Dhall *et al.* (2013).

Association of polar diameter was recorded significant and positive with equatorial diameter, bulb yield plant^{-1}, neck thickness, days to maturity and polar: equatorial. The findings were in agreement to Hosamani *et al.* (2010), Awale Degewione *et al.* (2011), Dhall *et al.* (2013) and Saini*et al.* (2014). Equatorial diameter was recorded highly significant and positive with bulb yield plant^{-1}, neck thickness and days to maturity. The findings corroborated the earlier findings Hosamani *et al.* (2010), Dhotre *et al.* (2010), Awale Degewione *et al.* (2011), Saini *et al.* (2014).TSS was recorded highly significant and positive association with bulb yield plant^{-1}. The findings were in agreement to Hosamani *et al.* (2010), Dhotre *et al.* (2010), Barad *et al.* (2012) and Dewangan *et al.* (2014).

Path coefficient analysis

Path coefficient analysis (Table 3) of different characters contributing towards bulb yield plant^{-1} showed that polar diameter had the highest positive direct effect followed by plant height at 60,90 DAT, TSS, a number of leaves plant^{-1} at 90 DAT and polar: equatorial. The results are in propinquity with Aliya *et al.* (2007), Dhotre *et al.* (2010) and Hosamani *et al.* (2010) for polar diameter, Hosamani *et al.* (2010), Sharma *et al.* (2015) for plant height, Hosamani *et al.* (2010) for TSS, Barad *et al.* (2012), Barad *et al.* (2012) for bulb weight, polar: equatorial and Sharma *et al.* (2015) for number of leaves plant^{-1}. The characters polar diameter, plant height at 60 DAT, TSS, plant height at 90 DAT, the number of leaves plant^{-1} at 90 DAT and polar: equatorial had correlation coefficient values at par with their direct effect on bulb yield plant^{-1}. This indicates true relationships with bulb yield plant^{-1} and direct selection for these traits would result in higher breeding efficiency for improving yield. Thus, these traits might be reckoned as the most important component traits of bulb yield plant^{-1}. Whereas, equatorial diameter had the highest negative direct effect on bulb yield plant^{-1} followed by neck thickness, days to maturity, the number of leaves plant^{-1} at 30 DAT, the number of leaves plant^{-1} at 60 DAT and plant height at 30 DAT. The results are in propinquity with Dhall *et al.* (2013), Panigrahi *et al.* (2013) in Potato and Sharma *et al.* (2015). But equatorial diameter, neck thickness, days to maturity, the number of leaves plant^{-1} at 30 DAT, the number of leaves plant^{-1} at 60 DAT and plant height at 30 DAT was positively correlated to it. This indicated that the indirect effect was the cause of correlation, and the indirect causal factors are to be considered simultaneously for selection.

Quality parameters

Considerable variability was observed among the genotypes (Table 4, 5, 6, 7) for foliage character, bulb colour, bulb shape and bolting tendency. Shape, thecolour of onion bulb and foliage character in green onion is most important characteristics to help customers in choosing cultivars on the market. These results are in close harmony with the findings of Jain *et al.* (2015) for bulb shape and bulb colour.

Conclusion

It is concluded that all the genotypes are indicating the presence of genetic diversity in the existing material of onion genotypes under study. The highest production recorded in OSR-1344 and Agrifound Light Red. While, ON14-06 and ON14-15 are well-performing genotypes for biotic resistance. Also, the variability is important agronomical traits found to point out that these onion accessions could be candidates for future breeding programs. The correlation and path analysis could make the selection easier and evaluated the traits found could help to establish adequate selection strategies in onion.

Acknowledgements

The authors are highly acknowledged to Director Research Services, Director Instruction, Dean Collage of Agriculture, JNKVV and my Advisor Dr. P.K. Jain (Uni. Prof. and Head), Department of Horticulture, JNKVV Jabalpur (Madhya Pradesh) for help in conducting the trial successfully and continuous guidance and technical support during field investigation.

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