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Performance evaluation and scope of onion improvement under hot arid conditions

A. K. Verma*, P. P. Singh[1], D. Singh, P. L. Saroj and Major Singh[2]
ICAR-Central Institute for Arid Horticulture, Bikaner-334 006, Rajasthan, India.

ABSTRACT

The present investigation was carried out at the experimental farm of ICAR-CIAH, Bikaner Rajasthan during the rabi season of 2019 and 2020. A wide range of variability was reported for the characters, such as plant height at 60 DAS, leaves per plant, polar diameter, bulb weight, scales per bulb and bulb yield. Bhima Red, Bhima Kiran and Bhima Shakti were identified as the high-yielding varieties for cultivation under hot arid conditions during rabi season. The highest genotypic coefficient of variation was observed for bulb yield. Higher heritability estimates conjugated with high genetic advance as per cent of mean were recorded for plant height at 60 DAS, leaves per plant, bulb weight and bulb yield. Correlation coefficient analysis revealed that polar diameter, equatorial diameter, bulb weight and TSS had a significant positive correlation with bulb yield. Path analysis revealed the true association between yield and bulb weight, as the correlation was due to direct effect. Hence, selection based on these characters would be effective in further improvement of onion under hot arid conditions.

Keywords: *Allium cepa*, Genetic advance, Heritability, Arid climate.

INTRODUCTION

Onion (*Alliun cepa* L.) is one of the most important bulb as well as cash vegetable crop and belongs to family *Amaryllidaceae*. It is an important vegetable crop of India whose leafy portion is used as a vegetable and its bulbs are used as salad and spice. India ranks second in area and production of vegetables in the world after China with 8.48 million hectare area and 132.02 million tonnes production during 2019 (FAO, 2). In India, onion was grown in 1.62 million hectare with a production of 26.64 million tonnes during 2020-21 with an average productivity of 16.40 tonnes per hectare. In Rajasthan, onion was grown in 0.08 million hectare and produced 1.38 million tonnes during 2020-21 with an average productivity of 22.77 tonnes per hectare. It is a valuable foreign exchange earner and India is the third largest exporter after Netherlands and Spain and earned Rs. 2107.13 Crore through the export of onion during the year 2020-21 (NHRDF, 3). Hot arid zone is characterized by high temperature during summer but experiences severe winter too. Besides, the soil of this region is sandy in nature which together creates scope for cultivation of bulb crops. One such bulb crop is onion and Rajasthan has emerged as an important onion growing state during recent years, but there is a considerable gap between yield per unit and yield potential of the improved onion varieties. Onion has low productivity and quality particularly in arid region (Singh *et al.,* 15). Though, different institutions have developed several high yielding varieties, their productivity did not exhibit the same pattern under every agro-climatic condition (Dwivedi *et al*., 5). The improved varieties have a good potential to produce double yield when compared to a local variety (Joslin *et al.,* 7). No systematic study has been conducted to assess the suitable onion varieties for getting higher yield under hot arid environment of western Rajasthan. Thus, it becomes important to identify high yielding suitable varieties for this region.

For any crop improvement approach, sufficient variability is required for economically important traits in its gene pool. The importance of genetic diversity in crop has been highlighted by many researchers to choose the parents for recombination breeding. Studies on genetic parameters are basic requirement for the identification of elite material and improvement of traits based on selection. Knowledge gained through correlation coefficient analysis between yield and yield attributes helps to find out plant selection guide lines in terms of identifying important yield components. Path coefficient analysis further separates total correlation into direct and indirect effect which increases the effectiveness of the selection. Yield is a quantitative complex trait, which is controlled by a number of yield contributing traits. Thus, the knowledge of the correlation between yield and its contributing characters along with their relative contribution displayed by path analysis holds practical importance

*Corresponding authors mail: ajayhorti19@gmail.com
[1]ICAR-IIFSR, Modipuram-250110, Uttar Pradesh, India.
[2]ICAR-DOGR, Pune, Rajgurunagar-410505, Maharashtra, India.

in selection and provides basis for further breeding programme. Therefore, the present study was aimed at to study the performance of varieties, variability, heritability, genetic advance, character association among yield and its contributing traits to investigate the scope of onion improvement under hot arid conditions.

MATERIALS AND METHODS

The present experiment was conducted under hot arid agro -climatic conditions of ICAR-Central Institute for Arid Horticulture, Bikaner, Rajasthan under a collaborative project between ICAR-Central Institute for Arid Horticulture, Bikaner and ICAR-Directorate of Onion and Garlic Research, Pune. The experimental location is situated at 28° North latitude and 73°18' E longitude at an altitude of 235 m above mean sea level. The climate of this region experiences low and erratic rainfall (150-350 mm), high solar radiation and wind speed (12-16 km/h), extremes of temperatures (-4°C-48°C) with prolonged summer duration. Besides, the soil is sandy in nature which has poor fertility and water holding capacity. Eleven varieties *viz.* Bhima Red, Bhima Light Red, Bhima Dark Red, Bhima Shweta, Bhima Shubhra, Bhima Safed, Bhima Kiran, Bhima Shakti, Bhima Raj and Bhima Super from ICAR-DOGR, Pune and RO-252 from Rajasthan Agricultural Research Institute (RARI), Durgapura were evaluated in randomized block design replicated thrice during *rabi* season of 2019 and 2020. The crop was grown on drip system of cultivation. The observations were recorded on ten plants selected randomly from each replication for each genotype on thirteen quantitative characters *viz*. plant height at 60 DAS (cm), plant height at harvest (cm), leaves per plant, leaf length (cm), leaf diameter (cm), pseudostem length (cm), pseudostem diameter (cm), polar diameter (cm), equatorial diameter (cm), bulb weight (g), TSS (°Brix), scales per bulb and bulb yield (t/ha). The data of both the seasons were pooled and analyzed adopting standard statistical procedures using OP Sheoran Statistical Package (OPSTAT) of CCS Haryana Agricultural University, Hisar (Sheoran *et al.,* 16).

RESULTS AND DISCUSSION

Significant variations were observed among varieties with regard to growth and yield attributes (Table 1). Not a single variety was found the best for all the characters. This type of varietal differences in different growth and yield parameters of onion have also been reported by Dwivedi *et al.* (5), Sharma and Singh (14), Joslin *et al.* (7) and Khar *et al.* (8). Highest bulb yield was recorded by Bhima Red (44.85 t/ha) closely followed by Bhima Kiran (41.47 t/ha) and

Table 1. Mean performance of the various growth and yield attributes in different varieties of onion.

Variety	Plant height at 60 DAS (cm)	Plant height at harvest (cm)	Leaves per plant	Leaf length (cm)	Leaf diameter (cm)	Pseudostem length (cm)	Pseudostem diameter (cm)	Polar diameter of bulb (cm)	Equatorial diameter of bulb (cm)	Bulb weight (g)	TSS (°Brix)	Scales per bulb	Bulb yield (q/ha)
Bhima Shweta	33.82	62.80	15.30	36.48	4.23	12.00	1.95	6.01	7.14	157.40	12.66	8.00	34.01
Bhima Red	29.27	60.70	12.90	38.20	4.39	11.74	2.22	6.79	8.14	190.71	14.85	10.50	44.85
B. Dark Red	28.91	61.60	12.60	39.14	4.00	11.10	1.91	6.55	7.75	163.33	14.68	11.50	35.15
Bhima Kiran	27.36	61.00	11.50	43.41	4.17	10.06	1.86	6.65	7.53	161.74	14.55	9.00	41.47
Bhima Shakti	38.18	65.88	16.65	43.38	3.72	12.37	2.46	7.03	8.17	187.39	13.95	9.50	41.00
Bhima Safed	34.82	61.20	12.13	40.43	4.05	11.60	1.91	6.83	7.74	165.44	13.90	10.00	30.77
Bhima Raj	26.18	60.20	14.83	40.94	3.94	12.15	1.96	6.42	7.57	159.05	13.60	8.50	23.12
B. Shubhra	32.64	58.31	16.50	42.23	4.46	12.29	2.07	6.62	7.54	158.41	12.10	11.00	19.14
Bhima Super	22.50	63.00	14.55	42.94	4.03	11.90	2.14	5.36	6.71	115.00	11.75	8.50	26.22
B. Light Red	28.27	61.90	14.30	39.35	4.38	11.17	2.01	5.42	6.38	110.00	12.40	10.00	19.27
RO-252	38.30	60.30	13.50	47.05	3.68	11.50	1.93	5.51	7.22	120.39	12.00	9.50	20.10
SEm±	0.79	1.11	0.57	0.92	0.16	0.32	0.04	0.21	0.15	3.56	0.43	0.69	1.36
CV (%)	4.41	3.12	7.02	3.85	6.73	4.70	3.08	5.76	3.54	4.02	5.60	12.31	7.72
CD (P=0.05)	2.34	3.29	1.70	2.72	0.47	0.94	0.11	0.62	0.45	10.59	1.28	2.04	4.03

Bhima Shakti (41.00 t/ha) which were statistically at par with each others. Bhima Shubhra registered the lowest bulb yield (19.14 t/ha) which was statistically at par with Bhima Light Red (19.27 t/ha) and RO-252 (20.10 t/ha). The yield differences in different onion varieties at similar agro-climatic conditions were also observed by Khar *et al.* (8), Mitiku and Tadesse (12) and Khosa and Dhatt (9) as the performance of a variety is the result of interaction between gene and environment.

The PCV values were slightly greater than GCV for all the traits except leaf diameter and scales per bulb (Table 2) suggesting a very little influence of environment for their expression (Lakshmi, 10). This was in confirmation with the findings of Khosa and Dhatt (9), Dwivedi *et al.* (5) and Mohapatra *et al.,* (13). A wide range of difference between PCV and GCV for leaf diameter and scales per bulb indicates the susceptibility of these traits to environmental fluctuations (Lakshmi, 10). High magnitude of PCV and GCV (>20%) for bulb yield indicated that there is high genetic variation among the varieties for bulb yield potential. The results are similar to the findings of Dwivedi *et al.* (5), Lakshmi (10) and Mohapatra *et al.* (13).

High heritability conjugated with high genetic advance as per cent of mean is more effective and reliable in determining the effect of selection (Allard, 1; Johnson *et al*., 6). High heritability coupled with high genetic advance was recorded for plant height at 60 DAS, leaves per plant, bulb weight and bulb yield suggesting that these traits were governed by additive gene action and hence simple phenotypic selection for these traits would be effective. For phenotypic selection, breeding methods like mass selection or bulk method can be used. Similar results have been reported in onion by Dwivedi *et al.* (5), Lakshmi (10) and Mohapatra *et al.* (13).

Yield, being a complex quantitative character is controlled by a many factors. It is important to know the influence of each character on yield and correlation studies helps in this direction. In general, it is evident from the data recorded that genotypic correlation was higher than phenotypic correlation (Table 3) indicating strong inherent association of characters and relative stability of genotypes to the environment. Bulb yield exhibited highly significant positive association with polar diameter, equatorial diameter, bulb weight and TSS. These results are in consonance with the findings of Dewangan and Sahu (4), Mesenbet and Walle (11). Present findings emphasize the importance of these traits in direct selection for improvement of yield and its attributing traits in onion.

The results of the path showing the cause and effect relationship are presented in Table 4. Among all the traits under study, bulb weight exhibited very high and high positive direct effect on bulb yield at phenotypic and genotypic level, respectively. The findings are also supported with the reports of Mesenbet and Walle (11) for bulb weight. The other traits *viz.* TSS (at genotypic level only) and pseudostem diameter also exhibited high positive direct effect on bulb yield. Polar and equatorial

Table 2. Estimates of variability, heritability and genetic advance as per cent of mean for growth and yield attributes of onion.

S. No.	Character	Range		Mean	PCV	GCV	Heritability (%)	Genetic advance as percent of mean
		Minimum	Maximum					
1.	Plant height at 60 DAS (cm)	22.50	38.30	30.93	16.67	16.08	93.01	31.95
2.	Plant height at harvest (cm)	58.31	65.88	61.54	4.05	2.59	40.71	3.40
3.	Leaves per plant	11.50	16.65	14.07	13.43	11.44	72.63	20.09
4.	Leaf length (cm)	36.48	43.41	41.23	7.83	6.82	75.88	12.24
5.	Leaf diameter (cm)	3.68	4.46	4.10	8.39	5.01	35.62	6.16
6.	Pseudostem length (cm)	10.06	12.37	11.62	6.90	5.05	53.61	7.62
7.	Pseudostem diameter (cm)	1.86	2.46	2.04	9.02	8.47	88.31	16.40
8.	Polar diameter of bulb (cm)	5.36	7.03	6.29	10.77	9.09	71.35	15.82
9.	Equatorial diameter of bulb (cm)	6.38	8.17	7.45	7.96	7.12	80.15	13.14
10.	Bulb weight (g)	110.00	190.71	153.53	18.00	17.54	95.01	35.23
11.	TSS (^{o}Brix)	11.75	14.85	13.31	9.85	8.11	67.72	13.74
12.	Scales per bulb	8.00	11.50	9.64	15.19	8.90	34.31	10.74
13.	Bulb yield (q/ha)	19.14	44.85	30.46	31.89	30.94	94.14	61.84

Table 3. Genotypic (G) and phenotypic (P) correlation coefficients among yield and yield attributes in different varieties of onion.

		X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
X1	G	**1.000**											
	P	**1.000**											
X2	G	0.135	**1.000**										
	P	0.194	**1.000**										
X3	G	0.277	0.474**	**1.000**									
	P	0.177	0.016	**1.000**									
X4	G	0.229	-0.222	0.129	**1.000**								
	P	0.278	0.122	-0.114	**1.000**								
X5	G	-0.501**	-0.923**	-0.001	-0.824**	**1.000**							
	P	-0.273	-0.063	-0.036	-0.380*	**1.000**							
X6	G	0.324	0.196	0.994**	-0.125	-0.102	**1.000**						
	P	0.227	0.113	0.579**	-0.040	-0.126	**1.000**						
X7	G	0.188	0.737**	0.663**	0.053	-0.102	0.658**	**1.000**					
	P	0.206	0.414*	0.475**	0.110	-0.164	0.487**	**1.000**					
X8	G	0.288	0.083	-0.047	-0.209	0.139	0.069	0.220	**1.000**				
	P	0.252	-0.062	-0.088	-0.101	-0.081	0.091	0.314	**1.000**				
X9	G	0.391*	0.054	-0.093	-0.030	-0.209	0.210	0.367*	0.978**	**1.000**			
	P	0.344*	0.019	-0.044	-0.003	-0.203	0.136	0.316	0.711**	**1.000**			
X10	G	0.291	0.197	-0.046	-0.279	0.063	0.212	0.377*	0.953**	0.982**	**1.000**		
	P	0.234	0.011	0.057	-0.347*	0.014	0.134	0.315	0.819**	0.848**	**1.000**		
X11	G	-0.027	0.144	-0.625**	-0.305	-0.161	-0.399*	0.104	0.989**	0.850**	0.827**	**1.000**	
	P	-0.058	0.069	-0.360*	-0.320	0.133	-0.306	-0.060	0.464**	0.590**	0.709**	**1.000**	
X12	G	0.271	-0.184	-0.456**	0.156	0.490**	-0.126	0.122	0.534**	0.487**	0.205	0.320	**1.000**
	P	0.016	-0.461**	0.116	-0.314	0.099	-0.087	-0.033	0.197	0.214	0.296	0.304	**1.000**
X13	G	0.049	0.544**	-0.370*	-0.273	-0.052	-0.224	0.347*	0.703**	0.689**	0.755**	0.842**	-0.036
	P	0.027	0.335	-0.252	-0.300	0.021	-0.259	0.271	0.506**	0.596**	0.745**	0.744**	0.085

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

X1=Plant height at 60 DAS, X2=Plant height at harvest, X3=Leaves per plant, X4=Leaf length, X5=Leaf diameter, X6=Pseudostem length, X7=Pseudostem diameter, X8=Polar diameter of bulb, X9=Equatorial diameter of bulb, X10=Bulb weight, X11=TSS, X12=Scales per bulb and X13=Bulb yield

diameter recorded low and high negative direct effect, respectively but had positive correlation with bulb yield indicating the indirect effects seem to be cause of correlation. In this situation, the indirect causal factors are to be considered simultaneously for selection based on such traits. The similar findings were observed by Lakshmi (10) for polar diameter.

Based on performance evaluation, it can be concluded that the onion has the potential to be cultivated for high quality bulb yield under hot arid conditions. No incidence of any pest or disease was observed in any of the variety under field conditions. The adoption of the varieties *viz.* Bhima Red, Bhima Kiran and Bhima Shakti can improve onion production during *rabi* season under hot arid conditions. From variability, heritability and genetic advance studies, direct phenotypic selection based on plant height at 60 DAS, leaves per plant, bulb weight and bulb yield would be effective for improvement of onion. Correlation coefficient analysis revealed that polar diameter, equatorial diameter, bulb weight and TSS had the significant positive correlation with bulb yield. Path analysis revealed that bulb weight had high positive direct effect on bulb yield. These were identified as superior yield components and direct selection based on above traits will be effective for yield improvement in onion. Further, the genotypes which showed better performance for these traits

Table 4. Direct and indirect effects of various yield and yield attributes on bulb yield in different varieties of onion.

		X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
X1	G	**0.449**	-0.056	-0.006	-0.031	-0.005	-0.165	0.187	-0.045	-0.218	0.095	-0.028	-0.127
	P	**-0.095**	0.045	-0.068	-0.004	0.029	-0.087	0.062	-0.141	-0.095	0.370	0.012	0.000
X2	G	0.061	**-0.417**	-0.011	0.030	-0.010	-0.100	0.731	-0.013	-0.030	0.064	0.153	0.086
	P	-0.018	**0.233**	-0.006	-0.002	0.007	-0.044	0.125	0.035	-0.005	0.017	-0.014	0.007
X3	G	0.124	-0.197	**-0.023**	-0.017	0.000	-0.507	0.657	0.007	0.052	-0.015	-0.663	0.213
	P	-0.017	0.004	**-0.386**	0.001	0.004	-0.223	0.144	0.049	0.012	0.090	0.071	-0.002
X4	G	0.103	0.093	-0.003	**-0.134**	-0.009	0.064	0.053	0.032	0.017	-0.091	-0.324	-0.073
	P	-0.026	0.028	0.044	**-0.013**	0.040	0.015	0.033	0.057	0.001	-0.547	0.063	0.005
X5	G	-0.225	0.385	0.000	0.110	**0.011**	0.052	-0.101	-0.021	0.117	0.021	-0.170	-0.229
	P	0.026	-0.015	0.014	0.005	**-0.105**	0.048	-0.050	0.045	0.056	0.023	-0.026	-0.001
X6	G	0.146	-0.081	-0.023	0.017	-0.001	**-0.510**	0.652	-0.011	-0.117	0.069	-0.423	0.059
	P	-0.021	0.026	-0.224	0.001	0.013	**-0.385**	0.147	-0.051	-0.038	0.211	0.060	0.001
X7	G	0.085	-0.307	-0.015	-0.007	-0.001	-0.336	**0.991**	-0.034	-0.205	0.123	0.110	-0.057
	P	-0.020	0.097	-0.184	-0.001	0.017	-0.188	**0.303**	-0.176	-0.087	0.497	0.012	0.000
X8	G	0.129	-0.034	0.001	0.028	0.002	-0.035	0.218	**-0.155**	-0.584	0.334	1.049	-0.249
	P	-0.024	-0.014	0.034	0.001	0.008	-0.035	0.095	**-0.560**	-0.197	1.291	-0.092	-0.003
X9	G	0.176	-0.022	0.002	0.004	-0.002	-0.107	0.364	-0.162	**-0.557**	0.321	0.901	-0.227
	P	-0.033	0.004	0.017	0.000	0.021	-0.052	0.096	-0.398	**-0.277**	1.337	-0.117	-0.003
X10	G	0.131	-0.082	0.001	0.037	0.001	-0.108	0.373	-0.159	-0.548	**0.326**	0.877	-0.096
	P	-0.022	0.003	-0.022	0.005	-0.002	-0.051	0.095	-0.458	-0.235	**1.577**	-0.140	-0.004
X11	G	-0.012	-0.060	0.014	0.041	-0.002	0.204	0.103	-0.153	-0.474	0.270	**1.061**	-0.149
	P	0.006	0.016	0.139	0.004	-0.014	0.118	-0.018	-0.260	-0.163	1.118	**-0.198**	-0.005
X12	G	0.122	0.077	0.010	-0.021	0.005	0.064	0.121	-0.083	-0.271	0.067	0.339	**-0.467**
	P	-0.002	-0.108	-0.045	0.004	-0.010	0.033	-0.010	-0.110	-0.059	0.467	-0.060	**-0.015**
r	G	0.049	0.544**	-0.370*	-0.273	-0.052	-0.224	0.347*	0.703**	0.689**	0.755**	0.842**	-0.036
	P	0.027	0.335	-0.252	-0.300	0.021	-0.259	0.271	0.506**	0.596**	0.745**	0.744**	0.085

Genotypic residual effect=0.038 and Phenotypic residual effect=0.065; Diagonal (bold) values indicate direct effects

can be used in breeding programmes. Thus, there is a great scope of onion cultivation and its further improvement for quality bulb yield, productivity and profitability under hot arid agro-climatic conditions.

AUTHORS' CONTRIBUTION

Conceptualization of research (AKV, PPS, PLS, MS); Designing of the experiments (AKV, PPS); Contribution of experimental materials (MS); Execution of field/lab experiments and data collection (AKV, PPS); Analysis of data and interpretation (AKV); Preparation of the manuscript (AKV, DS, MS).

DECLARATION

The authors declare no conflict of interest.

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