Environment and Ecology 41 (4) : 2320—2330, October—December 2023
Article DOI: https://doi.org/10.60151/envec/LCDB7460
ISSN 0970-0420

Genetic Variability, Correlation and Path Coefficient Analysis of Ash Gourd (*Benincasa hispida* (Thunb.) Cogn.) Genotypes

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Received 15 January 2023, Accepted 5 May 2023, Published on 12 October 2023

ABSTRACT

The present investigation was carried out during *kharif* season, 2018-2019 on 37 genotypes of ash gourd in Randomized Block Design to study the genetic variability, heritability, genetic advances, correlation and path coefficient. Results revealed high genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) for seediness (44.197 and 44.09), fruit diameter (36.41 and 36.26), average fruits weight (32.308 and 32.27), number of lobes (21.73 and 21.63), peduncle length (25.72 and 25.651), petiole length (22.25 and 22.02), fruit length (25.82 and 25.68), seed width (24.84 and 24.62), number of fruit per plant (21.93 and 21.81), nodes at which first female flower appears (28.54 and 28.48), yield per plant (25.35 and 25.11) and yield per hectare (25.35 and 25.11), respectively. Whereas, high heritability (h^2) coupled with genetic advance over mean (GAM) was registered highest in seediness (99.52% and 90.61%) followed by fruit diameter (99.23% and 74.41%), fruit length (98.87% and 52.60%), respectively. Fruit yield per plant showed highly significant positive phenotypic and genotypic correlation coefficients with avg fruit weight (0.708 and 0.709), vine length (0.359 and 0.368), fruit diameter (0.304 and 0.307), seed width (0.337 and 0.342), crop duration (0.370 and 0.356) and cotyledon length (0.295 and 0.305), respectively. The highest positive direct effects on fruit yield was exerted by average fruit weight (1.034) followed by number of fruit/plant (0.738) and vine length (0.062) whereas number of lobes (-0.087) shown highest negative direct effect followed by ovary length (-0.062) and cotyledon width (-0.059).

Keywords Ash gourd, Genetic variability, Heritability, Correlation, Path analysis.

INTRODUCTION

Ash gourd (*Benincasa hispida* (Thunb) Cogn.) is a cucurbitaceous vegetable crop with chromosome number 2n=24, grown under wide agro climatic conditions. The original home of ash gourd is believed to be Java, where its wild progenitors are still found.

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However, it is widely distributed throughout the tropical and subtropical Asia. Though, it has been cultivated in China from the ancient period, it is not clearly known from what time this crop is being cultivated in the Indian subcontinent. It is believed that this has originated in Asia. It is preferred among the growers and consumers because of long shelf life under ambient conditions, good portability and appreciably good nutritive value. It comes in the market when there is a crisis of vegetables. Among the vegetables under Cucurbitaceae family and other creepers usually ash gourd gives the higher economic return for marginal farmers. Normally the entire ash gourd plant, including fruit peel, flower, seed, and leaves are used. Ash gourd has great use in Ayurveda, confectionary and medicine preparations. The mature fleshy fruit is either eaten raw or cooked as vegetable marrow or 'candied' as sweet meat popularly known as 'petha'. Ash gourd is considered good for people suffering from nervousness and debility. It is a good source of carbohydrate, vitamin A, vitamin C and minerals like iron and zinc (Kanaujia *et al.* 2017). On compositional basis, petha based sweets contain on average basis of total fat 0.4%, total carbohydrate 65%, dietary fiber 3%, protein 0.6% and sugar content 40%. Its fruits contain a relatively high level of K and low Na and from the index of nutritional quality value, it has been adjudged as a quality vegetable. Chalky wax on its skin prevents micro-organisms growth and preserves it. It is an excellent source of vitamin B_1, vitamin B_3, vitamin C and nutrients i.e., calcium, potassium, iron and zinc (Sureja *et al.* 2006). Even though having wider industrial importance, relatively less attention has been paid towards the varietal improvement of existing strains available in different parts of the country. Considering the potentiality of this crop, there is a need to develop varieties suitable for cultivation under specific agro-ecological conditions. A thorough knowledge regarding the amount of genetic variability existing for various characters is essential for initiating the crop improvement program. North East has good genetic variability for various traits in ash gourd and no exploration has been taken to tap the diversity till now. So, there is need to develop a variety(ies) by identifying good qualitative and yield traits, suitable for cultivation in this region. Since such studies are very meager particularly under Northeastern India conditions, the present investigation was carried out with a set of varieties and landraces of ash gourd.

MATERIALS AND METHODS

The present investigation on "Evaluation of genetic variability, heritability and genetic advances in ash gourd (*Benincasa hispida* (thunb.) Cogn.) genotypes" was carried out at horticultural farm at School of Agricultural Sciences and Rural Development, Medziphema, Nagaland University in the year 2018 and 2019 (Table 1). The experiment was carried out following Randomized Block Design in three replications with 37 genotypes of ash gourd. The sowing of experimental material for first year was done on 2^{nd} April, 2018 and for second year on 30^{th} March, 2019. The seeds are sown in direct field at the distance 4 m for row to row and 0.6 cm for plant to plant was maintained and the plot size was 19.2 m^2. All recommended package of practices were followed for raising the good crop. The observation were recorded on five randomly selected plants from each plot in each replication for the following 26 quantitative characters viz. cotyledon length, cotyledon width, number of primary branches, leaf length, leaf width, number of lobes, intermodal length, petiole length, peduncle length, days to 1^{st} female flower, nodes at which 1^{st} female flower appears, ovary length, no. of fruit/plant, fruit length, fruit diameter, average fruit weight, vine length, seed length, seed width, seediness, seed weight, flesh thickness, vit C, TSS, crop duration and yield/plant.

The mean values over replications were subjected for analyzing the various parameters. The genotypic and phenotypic variance, genotypic and phenotypic coefficient of variation, heritability and genetic advance were estimated. The data were also analyzed for estimating the correlation coefficient and path analysis for grain yield and its component characters.

RESULTS AND DISCUSSION

Genetic variability, heritability and genetic advance

The analysis of variance revealed significant differ-

Table 1. Genetic parameters on yield and qualitative attributes of thirty seven ash gourd genotypes.

Characters	Year	Mean	Range Min	Range Max	Coefficient of variance PVC (%)	Coefficient of variance GCV (%)	Heritability (%)	Genetic advance as % of mean
Cotyledon length (cm)	2018	2.89	2.31	4.16	15.235	12.212	64.25	20.164
	2019	2.853	2.20	4.00	15.163	11.714	59.683	18.642
	Pooled	2.88	2.30	4.08	13.12	12.88	96.36	26.04
Cotyledon width (cm)	2018	1.56	1.15	2.35	19.804	18.433	86.636	35.344
	2019	1.55	1.13	2.29	19.495	18.458	89.645	36.002
	Pooled	1.56	1.15	2.32	18.855	18.78	99.2	38.53
Length of internodes (cm)	2018	13.52	8.93	17.56	17.01	15.647	84.616	29.649
	2019	13.406	8.91	18.34	16.806	15.459	84.609	29.292
	Pooled	13.42	8.92	17.95	15.972	15.81	97.99	32.24
Number of primary branches	2018	3.35	2.67	4.10	14.535	11.55	63.143	18.91
	2019	3.287	2.75	3.92	15.828	10.403	43.194	14.084
	Pooled	3.33	2.71	4.00	12.389	12.01	94.01	23.99
Vine length (m)	2018	6.05	3.85	8.04	19.041	18.357	92.946	36.457
	2019	5.938	3.75	8.15	19.071	18.521	94.318	37.054
	Pooled	6.01	3.80	7.98	18.558	18.28	96.99	37.08
Leaf length (cm)	2018	13.35	10.27	18.22	17.164	16.37	90.954	32.16
	2019	13.147	10.27	17.45	17.513	16.435	88.07	31.773
	Pooled	13.14	10.37	17.59	16.322	16	96.06	32.3
Leaf width (cm)	2018	18.32	13.54	24.2	17.073	16.167	89.673	31.53
	2019	18.013	13.28	24.14	17.757	16.997	91.622	33.515
	Pooled	18.07	13.41	23.97	16.771	16.46	96.38	33.3
Number of lobes	2018	5.83	1.05	7.34	22.105	21.969	98.77	44.97
	2019	5.703	0.98	7.20	21.634	21.496	98.725	43.999
	Pooled	5.81	1.01	7.10	21.731	21.63	99.11	44.37
Petiole length (cm)	2018	11.85	7.00	19.96	22.635	21.499	90.217	42.066
	2019	11.709	6.65	21.03	24.227	23.266	92.22	46.026
	Pooled	11.64	6.82	20.50	22.251	22.02	97.92	44.88
Days to first female flower appears	2018	74.01	60.79	92.00	10.933	10.695	95.696	21.552
	2019	74.026	60.20	90.23	10.844	10.498	93.712	20.934
	Pooled	74.46	60.50	91.12	10.64	10.51	97.52	21.38
Nodes at which first female flower appears	2018	19.25	9.29	30.66	27.737	27.513	98.395	56.221
	2019	19.329	9.20	29.8	27.716	27.484	98.336	56.145
	Pooled	19.61	9.25	29.93	28.547	28.48	99.55	58.54
Ovary length (cm)	2018	2.97	2.14	4.62	18.454	16.671	81.61	31.024
	2019	2.908	2.10	4.53	16.801	15.077	80.53	27.871
	Pooled	2.92	2.12	4.58	17.25	16.96	96.62	34.33
Peduncle length (cm)	2018	6.54	3.34	9.30	25.853	25.283	95.64	50.935
	2019	6.443	3.26	9.47	26.147	25.545	95.452	51.412
	Pooled	6.47	3.30	9.37	25.724	25.51	98.35	52.12
Seediness	2018	734.75	318.63	1489.54	45.393	45.186	99.088	92.657
	2019	722.55	313.79	1466.92	46.494	46.281	99.087	94.903
	Pooled	703.16	316.21	1478.23	44.197	44.09	99.52	90.61
Seed length (cm)	2018	1.07	0.69	1.45	17.083	14.89	75.968	26.734
	2019	1.052	0.67	1.32	17.615	15.982	82.313	29.869
	Pooled	1.06	0.68	1.38	18.321	18.05	97.03	36.62
Seed width (cm)	2018	0.57	0.35	0.86	24.64	24.011	94.922	48.19
	2019	0.567	0.34	0.85	25.756	25.13	95.203	50.512
	Pooled	0.57	0.35	0.85	24.845	24.62	98.2	50.26
Fruit length (cm)	2018	24.4	13.78	50.92	25.683	25.406	97.85	51.77
	2019	23.99	13.51	49.69	25.853	25.639	98.34	52.379
	Pooled	24.02	13.65	50.3	25.827	25.68	98.87	52.6
Fruit diameter (cm)	2018	18.78	8.76	55.96	51.934	51.822	99.57	106.52
	2019	18.468	8.51	56.33	52.51	52.396	99.568	107.704
	Pooled	18.53	8.63	56.15	52.499	52.41	99.68	107.8

Table 1. Continued.

Characters	Year	Mean	Range Min	Max	Coefficient of variance PVC (%)	GCV (%)	Heritability (%)	Genetic advance as % of mean
	2018	3.9	2.75	5.34	18.441	18.265	98.101	37.267
Flesh thickness	2019	3.825	2.82	5.66	18.647	18.47	98.114	37.687
(cm)	Pooled	3.84	2.80	5.50	18.321	18.05	97.03	36.62
	2018	121.65	101.97	143.82	9.337	8.803	88.894	17.09
Crop duration	2019	121.531	105	137.5	8.632	8.329	93.109	16.556
(days)	Pooled	121.09	103.48	140.4	8.515	8.36	96.41	16.91
	2018	4.94	3.33	7.16	23.228	22.382	92.854	44.42
Number of	2019	4.937	3.13	7.23	23.195	23.002	98.348	46.992
fruits per plant	Pooled	4.98	3.23	7.16	21.931	21.81	98.89	44.68
	2018	3167.46	1828.48	5711.46	31.802	31.691	99.305	65.057
Average fruits	2019	3,166.78	1826.23	5819.45	31.681	31.55	99.174	64.723
weight (g)	Pooled	3132.52	1827.36	5762.25	32.308	32.27	99.75	66.39
	2018	4.49	2.93	5.75	17.739	17.574	98.156	35.86
100 seed wt (g)	2019	4.403	2.81	5.53	18.3	18.141	98.265	37.045
	Pooled	4.42	2.87	5.64	17.905	17.8	98.82	36.45
	2018	2.15	1.30	3.00	20.802	20.558	97.67	41.85
TSS	2019	2.156	1.31	3.00	20.932	20.625	97.092	41.866
	Pooled	2.17	1.31	3.00	19.607	19.53	99.24	40.08
	2018	39.45	34.12	44.65	7.865	7.474	90.29	14.63
Vitamin C	2019	39.458	33.87	46.48	8.607	8.257	92.031	16.318
(mg/100 gm)	Pooled	39.64	34.13	45.17	7.888	7.71	95.55	15.53
	2018	15.12	8.74	22.94	25.83	24.906	92.977	49.47
Yield/Plant (kg)	2019	15.097	8.12	23.87	25.664	24.991	94.821	50.131
	Pooled	15.09	8.43	23.41	25.358	25.11	98.07	51.23

ences among the genotypes for all characters studied indicating a high degree of variability in the material. However, phenotypic coefficient of variation (PCV) was always higher than their respective genotypic coefficient of variation (GCV) for all the traits indicating environmental factors influencing the characters (Table 1). It is estimated that high genotypic and phenotypic coefficient of variation was observed for fruit diameter (52.49 and 52.41), seediness (44.197 and 44.09), average fruits weight (32.308 and 32.27), nodes at which first female flower appears (28.54 and 28.48), fruit length (25.82 and 25.68), peduncle length (25.72 and 25.51), seed width (24.84 and 24.62), petiole length (22.25 and 22.02), number of fruit per plant (21.93 and 21.81), number of lobes (21.73 and 21.63) and yield per plant (25.35 and 25.11). This high value of PCV and GCV indicated that maximum variability exists in these traits and there is enough scope for further improvement. Whereas low PCV and GCV were found in the characters like crop duration (8.51 and 8.36) and Ascorbic acid content (7.88 and 7.71). Selection for these traits may not have significant effect for improvement programe. Similar finding were also reported earlier by Gayen and Hossain (2007) and Pandit *et al.* (2009).

Heritability governed the resemblance between parents and their progeny whereas, the genetic advance provide the knowledge about expected gain for a particular character after selection. Heritability suggests the relative role of genetic factors in expression of phenotypes and also acts as an index of transmissibility of a particular trait to its off springs. Hence, that heritability in combination with genetic advance would be more reliable for predicting effects of selection because genetic advance depends on amount of genetic variability, magnitude of masking effect of genetic expression (environmental influence) and the intensity of selection. However, it is not necessary that a character showing high heritability will also exhibit high genetic advance. In present experiment, it is found that almost all the characters are showing high heritability and also high genetic advance except crop duration and ascorbic acid content. However, among

Table 2. Phenotypic correlation coefficient between fruit yield and its component characters in ash gourd.

	CL	CW	LOI	NPB	VL	LL	LW	NOL	PL	DFFF	NFFF	OL	PEDL
CL													
CW	0.649**												
LOI	0.347**	0.338**											
NPB	0.324**	0.271*	0.122NS										
VL	0.101NS	-0.125NS	0.086NS	-0.167NS									
LL	0.434**	0.487**	0.596**	0.323**	0.290*								
LW	0.490**	0.561**	0.623**	0.386**	0.279*	0.941**							
NOL	0.177NS	0.194NS	0.281*	0.089NS	-0.064NS	0.263*	0.315**						
PL	0.595**	0.635**	0.594**	0.416**	0.044NS	0.729**	0.805**	0.300**					
DFFF	-0.093NS	-0.220NS	-0.033NS	-0.132NS	0.231*	-0.023NS	-0.048NS	-0.118NS	-0.148NS				
NFFF	-0.098NS	-0.341**	-0.244*	-0.270*	0.166NS	-0.369**	-0.332**	-0.201NS	-0.245*	0.573**			
OL	-0.173NS	-0.117NS	0.133NS	0.155NS	-0.068NS	-0.104NS	-0.112NS	-0.160NS	-0.053NS	-0.117NS	-0.390**		
PEDL	-0.036NS	0.081NS	0.227NS	0.189NS	-0.245*	0.220NS	0.224NS	0.075NS	0.206NS	-0.048NS	-0.151NS	-0.023NS	
FL	0.184NS	0.076NS	-0.016NS	-0.121NS	0.408**	0.038NS	-0.006NS	-0.000NS	-0.090NS	0.104NS	-0.064NS	0.051NS	-0.163NS
FD	0.005NS	-0.179NS	0.123NS	-0.091NS	0.069NS	-0.151NS	-0.115NS	0.034NS	0.086NS	-0.213NS	0.235*	-0.163NS	-0.043NS
FT	0.522**	0.561**	0.316**	0.232*	0.122NS	0.530**	0.570**	0.307**	0.542**	-0.112NS	-0.076NS	-0.066NS	0.059NS
SEE	-0.214NS	-0.111NS	0.194NS	0.053NS	0.172NS	0.181NS	0.107NS	0.103NS	0.038NS	0.146NS	-0.025NS	0.069NS	0.218NS
SL	0.406**	0.494**	0.339**	0.142NS	0.135NS	0.336**	0.438**	0.219NS	0.553**	-0.191NS	0.007NS	-0.404**	0.133NS
SW	0.276*	0.437**	0.434**	0.125NS	0.126NS	0.473**	0.526**	0.145NS	0.571**	-0.179NS	-0.059NS	-0.403**	0.308**
CD	0.182NS	0.136NS	0.340**	0.161NS	0.097NS	0.088NS	0.196NS	0.200NS	0.364**	-0.182NS	0.079NS	-0.043NS	0.212NS
NFP	-0.353**	-0.616**	-0.333**	-0.189NS	-0.039NS	-0.579**	-0.549**	-0.262*	-0.553**	0.114NS	0.259*	0.103NS	-0.229*
AFW	0.557**	0.563**	0.332**	0.318**	0.318**	0.522**	0.579**	0.075NS	0.583**	0.022NS	-0.166NS	-0.159NS	0.185NS
SEW	0.215NS	0.353**	0.301**	0.250*	-0.186NS	0.396**	0.412**	0.291*	0.288*	-0.124NS	-0.497**	0.011NS	0.185NS
TSS	0.098NS	0.017NS	-0.026NS	-0.155NS	0.276*	-0.085NS	-0.081NS	-0.197NS	0.055NS	-0.131NS	0.246*	-0.062NS	-0.292*
VC	0.028NS	0.034NS	0.039NS	-0.047NS	-0.005NS	-0.058NS	-0.083NS	0.228NS	0.026NS	0.115NS	0.349**	-0.109NS	0.086NS
YIP	0.295*	0.102NS	0.060NS	0.211NS	0.359**	0.137NS	0.213NS	-0.160NS	0.195NS	0.084NS	0.013NS	-0.118NS	-0.018NS
YPH	0.295*	0.102NS	0.060NS	0.211NS	0.359**	0.137NS	0.213NS	-0.160NS	0.195NS	0.085NS	0.013NS	-0.118NS	-0.018NS

Table 2. Continued.

	FL	FD	FT	SEE	SL	SW	CD	NFP	AFW	SEW	TSS	VC	YIP
CL	-	-	-	-	-	-	-	-	-	-	-	-	-
CW	-	-	-	-	-	-	-	-	-	-	-	-	-
LOI	-	-	-	-	-	-	-	-	-	-	-	-	-
NPB	-	-	-	-	-	-	-	-	-	-	-	-	-
VL	-	-	-	-	-	-	-	-	-	-	-	-	-
LL	-	-	-	-	-	-	-	-	-	-	-	-	-
LW	-	-	-	-	-	-	-	-	-	-	-	-	-
NOL	-	-	-	-	-	-	-	-	-	-	-	-	-
PL	-	-	-	-	-	-	-	-	-	-	-	-	-
DFFF	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 2. Continued.

	FL	FD	FT	SEE	SL	SW	CD	NFP	AFW	SEW	TSS	VC	YIP
NFFF													
OL													
PEDL													
FL													
FD	0.195^{NS}												
FT	0.209^{NS}	-0.030^{NS}											
SEE	0.076^{NS}	-0.061^{NS}	0.090^{NS}										
SL	0.156^{NS}	0.465**	0.418**	0.002^{NS}									
SW	0.117^{NS}	0.503**	0.404**	0.064^{NS}	0.850**								
CD	-0.014^{NS}	0.534**	0.108^{NS}	0.207^{NS}	0.472**	0.423**							
NFP	-0.046^{NS}	0.222^{NS}	-0.556**	-0.225^{NS}	-0.443**	-0.383**	0.100^{NS}						
AFW	0.273*	0.088^{NS}	0.553**	0.068^{NS}	0.563**	0.559**	0.273*	-0.482**					
SEW	0.207^{NS}	-0.189^{NS}	0.331**	0.196^{NS}	0.232*	0.138^{NS}	0.133^{NS}	-0.300**	0.425**				
TSS	0.164^{NS}	0.181^{NS}	0.292*	-0.049^{NS}	0.305**	0.162^{NS}	-0.120^{NS}	-0.249*	0.075^{NS}	-0.276*			
VC	-0.123^{NS}	-0.152^{NS}	0.302**	0.065^{NS}	0.059^{NS}	-0.087^{NS}	-0.100^{NS}	-0.487**	-0.009^{NS}	-0.220^{NS}	0.430**		
YIP	0.266*	0.304**	0.167^{NS}	-0.114^{NS}	0.277*	0.337**	0.370**	0.264*	0.708**	0.200^{NS}	-0.087^{NS}	-0.412**	
YPH	0.266*	0.304**	0.167^{NS}	-0.113^{NS}	0.277*	0.337**	0.370**	0.264*	0.708**	0.200^{NS}	-0.087^{NS}	-0.412**	1.000**

CL-Cotyledon length, CW: Cotyledon width, LOI: Internodal length, NPB: Number of primary branches, VL: Vine length, LL: Leaf length, LW: Leaf width, NOL: Number of lobes, PL: Petiole length , DFFF: Days to first female flower, NFFF: Nodes of first female flower, OL: Ovary length, PEDL: Peduncle length, FL: Fruit length, FD: Fruit diameter, FT: Flesh thickness, SEE: Seediness, SL: Seed length, SW: Seed width, CD: Crop duration, NFP : Number of fruit per plant, AFW: Average fruit weight, SEW: 100 seed weight, TSS: TSS, VC: Ascorbic acid content.

these few most suitable character for selection with high heritability coupled with high genetic advance as percentage of mean was observed for traits like seediness (99.52% and 90.61%), fruit diameter (99.68% and 107.80%), fruit length (98.87% and 52.60%), peduncle length (98.35 % and 52.12%), seed width (98.20% and 50.26%), average fruit weight (99.75% and 66.39%), nodes of 1st female flower (99.55% and 58.54%), yield per plant (98.07% and 51.23%), respectively indicating that most likely the heritability is due to additive gene effects and were least affected by environmental variation where selection may be effective. The results are in conformity with Kumar *et al.* (2012) in bottle gourd genotypes.

Correlation

The findings clearly indicated that genotypic correlations were of higher magnitude to the corresponding phenotypic ones, thereby establishing strong inherent relationship among the characters studied (Tables 2 and 3). The low phenotypic value might be due to appreciable interaction of the genotypes with the environments. Correlation studies revealed that yield per plant showed highly significant positive phenotypic and genotypic correlation coefficients with cotyledon length (0.295 and 0.305), vine length (0.359 and 0.368), fruit length (0.266 and 0.274), fruit diameter (0.304 and 0.307), seed length (0.277 and 0.286), seed width (0.337 and 0.342), crop duration (0.370 and 0.356), number of fruit per plant (0.264 and 0.255) and avg fruit weight (0.708 and 0.709), respectively. On the other hand, highly significant negative phenotypic and genotypic correlation coefficients was found with ascorbic acid content (-0.412 and -0.453), respectively.

Hence, direct selection for these traits may lead to development of high yielding genotypes of ash gourd. Hence, direct selection for these traits may lead

Table 3. Genotypic correlation coefficient between fruit yield and its component characters in ash gourd.

	CL	CW	LOI	NPB	VL	LL	LW	NOL	PL	DFFF	NFFF	OL	PEDL
CL													
CW	0.650**												
LOI	0.336**	0.333**											
NPB	0.302**	0.264*	0.093^{NS}										
VL	0.108^{NS}	-0.124^{NS}	0.092^{NS}	-0.171^{NS}									
LL	0.444**	0.496**	0.605**	0.325**	0.276*								
LW	0.502**	0.571**	0.633**	0.393**	0.265*	0.940**							
NOL	0.181^{NS}	0.196^{NS}	0.287*	0.095^{NS}	-0.067^{NS}	0.271*	0.324**						
PL	0.616**	0.646**	0.607**	0.432**	0.028^{NS}	0.733**	0.812**	0.308**					
DFFF	-0.097^{NS}	-0.224^{NS}	-0.033^{NS}	-0.137^{NS}	0.238*	-0.025^{NS}	-0.052^{NS}	-0.120^{NS}	-0.147^{NS}				
NFFF	-0.102^{NS}	-0.344**	-0.249*	-0.283*	0.169^{NS}	-0.379**	-0.340**	-0.202^{NS}	-0.248*	0.573**			
OL	-0.209^{NS}	-0.134^{NS}	0.113^{NS}	0.120^{NS}	-0.067^{NS}	-0.114^{NS}	-0.121^{NS}	-0.163^{NS}	-0.051^{NS}	-0.118^{NS}	-0.399**		
PEDL	-0.043^{NS}	0.080^{NS}	0.225^{NS}	0.186^{NS}	-0.266*	0.201^{NS}	0.207^{NS}	0.076^{NS}	0.199^{NS}	-0.050^{NS}	-0.154^{NS}	-0.029^{NS}	
FL	0.189^{NS}	0.078^{NS}	-0.016^{NS}	-0.127^{NS}	0.404**	0.025^{NS}	-0.019^{NS}	0.002^{NS}	-0.107^{NS}	0.109^{NS}	-0.064^{NS}	0.054^{NS}	-0.173^{NS}
FD	0.002^{NS}	-0.181^{NS}	0.123^{NS}	-0.096^{NS}	0.063^{NS}	-0.164^{NS}	-0.126^{NS}	0.033^{NS}	0.084^{NS}	-0.216^{NS}	0.236*	-0.168^{NS}	-0.050^{NS}
FT	0.512**	0.559**	0.302**	0.203^{NS}	0.129^{NS}	0.540**	0.582**	0.314**	0.558**	-0.117^{NS}	-0.079^{NS}	-0.099^{NS}	0.054^{NS}
SEE	-0.222^{NS}	-0.113^{NS}	0.194^{NS}	0.052^{NS}	0.167^{NS}	0.173^{NS}	0.097^{NS}	0.104^{NS}	0.033^{NS}	0.147^{NS}	-0.026^{NS}	0.068^{NS}	0.213^{NS}
SL	0.424**	0.509**	0.351**	0.153^{NS}	0.106^{NS}	0.320**	0.427**	0.222^{NS}	0.552**	-0.198^{NS}	0.007^{NS}	-0.416**	0.117^{NS}
SW	0.288*	0.446**	0.444**	0.133^{NS}	0.108^{NS}	0.468**	0.522**	0.147^{NS}	0.570**	-0.184^{NS}	-0.060^{NS}	-0.409**	0.301**
CD	0.185^{NS}	0.137^{NS}	0.349**	0.170^{NS}	0.104^{NS}	0.093^{NS}	0.203^{NS}	0.205^{NS}	0.383**	-0.217^{NS}	0.071^{NS}	-0.045^{NS}	0.218^{NS}
NFP	-0.358**	-0.622**	-0.339**	-0.195^{NS}	-0.039^{NS}	-0.596**	-0.564**	-0.265*	-0.559**	0.104^{NS}	0.257*	0.107^{NS}	-0.234*
AFW	0.567**	0.565**	0.335**	0.327**	0.323**	0.532**	0.589**	0.075^{NS}	0.592**	0.015^{NS}	-0.170^{NS}	-0.163^{NS}	0.186^{NS}
SEW	0.221^{NS}	0.358**	0.306**	0.259*	-0.197^{NS}	0.400**	0.416**	0.288*	0.293*	-0.129^{NS}	-0.502**	0.011^{NS}	0.182^{NS}
TSS	0.096^{NS}	0.016^{NS}	-0.029^{NS}	-0.163^{NS}	0.282*	-0.088^{NS}	-0.084^{NS}	-0.199^{NS}	0.060^{NS}	-0.146^{NS}	0.243*	-0.065^{NS}	-0.296*
VC	0.026^{NS}	0.034^{NS}	0.038^{NS}	-0.050^{NS}	-0.002^{NS}	-0.060^{NS}	-0.088^{NS}	0.235*	0.036^{NS}	0.086^{NS}	0.346**	-0.114^{NS}	0.089^{NS}
YIP	0.305**	0.103^{NS}	0.060^{NS}	0.221^{NS}	0.368**	0.139^{NS}	0.216^{NS}	-0.163^{NS}	0.205^{NS}	0.067^{NS}	0.007^{NS}	-0.120^{NS}	-0.021^{NS}
YPH	0.305**	0.103^{NS}	0.060^{NS}	0.221^{NS}	0.368**	0.139^{NS}	0.216^{NS}	-0.164^{NS}	0.205^{NS}	0.067^{NS}	0.007^{NS}	-0.120^{NS}	-0.021^{NS}

Table 3. Continued.

	FL	FD	FT	SEE	SL	SW	CD	NFP	AFW	SEW	TSS	VC	YIP
CL	-	-	-	-	-	-	-	-	-	-	-	-	-
CW	-	-	-	-	-	-	-	-	-	-	-	-	-
LOI	-	-	-	-	-	-	-	-	-	-	-	-	-
NPB	-	-	-	-	-	-	-	-	-	-	-	-	-
VL	-	-	-	-	-	-	-	-	-	-	-	-	-
LL	-	-	-	-	-	-	-	-	-	-	-	-	-
LW	-	-	-	-	-	-	-	-	-	-	-	-	-
NOL	-	-	-	-	-	-	-	-	-	-	-	-	-
PL	-	-	-	-	-	-	-	-	-	-	-	-	-
DFFF	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 3. Continued.

	FL	FD	FT	SEE	SL	SW	CD	NFP	AFW	SEW	TSS	VC	YIP
NFFF													
OL													
PEDL													
FL													
FD	0.193^{NS}												
FT	0.214^{NS}	-0.033^{NS}											
SEE	0.072^{NS}	-0.065^{NS}	0.089^{NS}										
SL	0.146^{NS}	0.466**	0.436**	-0.008^{NS}									
SW	0.109^{NS}	0.504**	0.417**	0.059^{NS}	0.851**								
CD	-0.009^{NS}	0.545**	0.109^{NS}	0.210^{NS}	0.494**	0.436**							
NFP	-0.045^{NS}	0.223^{NS}	-0.568**	-0.227^{NS}	-0.454**	-0.389**	0.088^{NS}						
AFW	0.276*	0.087^{NS}	0.560**	0.068^{NS}	0.575**	0.564**	0.269*	-0.489**					
SEW	0.211^{NS}	-0.193^{NS}	0.339**	0.196^{NS}	0.230*	0.135^{NS}	0.135^{NS}	-0.304**	0.428**				
TSS	0.168^{NS}	0.182^{NS}	0.295*	-0.050^{NS}	0.313**	0.164^{NS}	-0.138^{NS}	-0.257*	0.072^{NS}	-0.279*			
VC	-0.120^{NS}	-0.156^{NS}	0.310**	0.065^{NS}	0.063^{NS}	-0.090^{NS}	-0.146^{NS}	-0.517**	-0.019^{NS}	-0.229*	0.424**		
YIP	0.274*	0.307**	0.170^{NS}	-0.116^{NS}	0.286*	0.342**	0.356**	0.255*	0.709**	0.201^{NS}	-0.099^{NS}	-0.453**	
YPH	0.274*	0.306**	0.170^{NS}	-0.116^{NS}	0.286*	0.342**	0.356**	0.255*	0.709**	0.201^{NS}	-0.099^{NS}	-0.453**	1.000**

CL-Cotyledon length, CW: Cotyledon width, LOI: Intermodal length, NPB: Number of primary branches, VL: Vine length, LL: Leaf length, LW: Leaf width, NOL: Number of lobes, PL: Petiole length , DFFF: Days to first female flower, NFFF: Nodes of first female flower, OL: Ovary length, PEDL: Peduncle length, FL: Fruit length, FD: Fruit diameter, FT: Flesh thickness, SEE: Seediness, SL: Seed length, SW: Seed width, CD: Crop duration, NFP : Number of fruit per plant, AFW: Average fruit weight, SEW: 100 seed weight, TSS: TSS, VC: Ascorbic acid content.

to the development of high yielding genotypes of ash gourd. The present findings are in conformity with Umamaheswarappa *et al.* (2004) who reported that fruit yield per ha had strong positive association with number of fruits per vine, fruit weight, fruit length and fruit girth. Similar results were also reported by Wani *et al.* (2008) and Bhardwaj *et al.* (2013).

Path analysis coefficient

Yield is a complex character and exhibits low heritability. Moreover, it is also affected by interactive effects of various traits and influenced by environmental factors, thus selection will be more effective based on those traits. The path coefficient analysis provides a more realistic picture of the interrelationship, as it considers direct as well as indirect effects of the variables by partitioning the correlation coefficients. In the present investigation, as shown in the Table 4, the path analysis revealed that on yield there is direct effects of average fruit weight (1.034), number of fruit/plant(0.738), vine length (0.062), flesh thickness (0.056), petiole leaf (0.054), seed width (0.048), number of primary branch (0.040), fruit diameter (0.040), 100 seed wt (0.026), crop duration (0.024), ascorbic acid content (0.019), leaf width (0.018), fruit length (0.004) and day to 1st female flower (0.003) whereas number of lobes (-0.087) shown highest negative direct effect followed by ovary length (-0.062), cotyledon width (-0.059), length of internodes (-0.046), seed length (-0.045), seediness (-0.035), TSS (-0.031) and leaf length (-0.025). The effect of residual factor (0.00288) on fruit yield per plot was negligible, thereby, suggested that no other major yield contributing component is left over. The present study suggested that more emphasis should be given to selecting genotypes having maximum average fruit weight and number fruits per plant and vine length. Ahmed *et al.* (2005) also reported that fruit weight, number of fruits per plant, fruit length had positive direct effect on fruit yield of bottle gourd. Similar results were obtained by Gayen and Hossain

Table 4. Direct and indirect effect of component character on fruit yield in ash gourd.

	CL	CW	LOI	NPB	VL	LL	LW	NOL	PL	DFFF	NFFF	OL	PEDL
CL	**-0.062**	-0.039	-0.016	0.012	0.007	-0.011	0.009	-0.016	0.033	0.000	0.009	0.015	0.003
CW	-0.040	**-0.059**	-0.015	0.010	-0.008	-0.012	0.010	-0.017	0.035	-0.001	0.029	0.010	-0.005
LOI	-0.021	-0.020	**-0.046**	0.004	0.006	-0.015	0.011	-0.025	0.033	0.000	0.021	-0.008	-0.014
NPB	-0.019	-0.016	-0.004	**0.040**	-0.011	-0.008	0.007	-0.008	0.023	0.000	0.024	-0.009	-0.012
VL	-0.007	0.007	-0.004	-0.007	**0.062**	-0.007	0.005	0.006	0.002	0.001	-0.014	0.005	0.017
LL	-0.027	-0.029	-0.028	0.013	0.017	**-0.025**	0.017	-0.024	0.040	0.000	0.032	0.008	-0.012
LW	-0.031	-0.034	-0.029	0.016	0.016	-0.023	**0.018**	-0.028	0.044	0.000	0.029	0.009	-0.013
NOL	-0.011	-0.012	-0.013	0.004	-0.004	-0.007	0.006	**-0.087**	0.017	0.000	0.017	0.012	-0.005
PL	-0.038	-0.038	-0.028	0.017	0.002	-0.018	0.014	-0.027	**0.054**	0.000	0.021	0.004	-0.012
DFFF	0.006	0.013	0.002	-0.005	0.015	0.001	-0.001	0.010	-0.008	**0.003**	-0.049	0.009	0.003
NFFF	0.006	0.020	0.012	-0.011	0.011	0.009	-0.006	0.018	-0.013	0.002	**-0.085**	0.029	0.010
OL	0.013	0.008	-0.005	0.005	-0.004	0.003	-0.002	0.014	-0.003	0.000	0.034	**-0.073**	0.002
PEDL	0.003	-0.005	-0.010	0.007	-0.017	-0.005	0.004	-0.007	0.011	0.000	0.013	0.002	**-0.062**
FL	-0.012	-0.005	0.001	-0.005	0.025	-0.001	0.000	0.000	-0.006	0.000	0.005	-0.004	0.011
FD	0.000	0.011	-0.006	-0.004	0.004	0.004	-0.002	-0.003	0.005	-0.001	-0.020	0.012	0.003
FT	-0.032	-0.033	-0.014	0.008	0.008	-0.013	0.010	-0.027	0.030	0.000	0.007	0.007	-0.003
SEE	0.014	0.007	-0.009	0.002	0.010	-0.004	0.002	-0.009	0.002	0.000	0.002	-0.005	-0.013
SL	-0.026	-0.030	-0.016	0.006	0.007	-0.008	0.008	-0.019	0.030	-0.001	-0.001	0.030	-0.007
SW	-0.018	-0.026	-0.020	0.005	0.007	-0.012	0.009	-0.013	0.031	-0.001	0.005	0.030	-0.019
CD	-0.011	-0.008	-0.016	0.007	0.006	-0.002	0.004	-0.018	0.021	-0.001	-0.006	0.003	-0.014
NFP	0.022	0.037	0.016	-0.008	-0.002	0.015	-0.010	0.023	-0.030	0.000	-0.022	-0.008	0.014
AFW	-0.035	-0.034	-0.015	0.013	0.020	-0.013	0.010	-0.007	0.032	0.000	0.014	0.012	-0.012
SEW	-0.011	-0.024	-0.012	0.007	-0.003	-0.016	0.010	-0.033	0.024	-0.001	0.033	0.015	-0.017
TSS	-0.006	-0.001	0.001	-0.006	0.018	0.002	-0.001	0.017	0.003	0.000	-0.021	0.005	0.018
VC	-0.002	-0.002	-0.002	-0.002	0.000	0.001	-0.002	-0.020	0.002	0.000	-0.030	0.008	-0.006

Table 4. Continued.

	FL	FD	FT	SEE	SL	SW	CD	NFP	AFW	SEW	TSS	VC
CL	0.001	0.000	0.028	0.007	-0.019	0.014	0.004	-0.264	0.587	0.005	-0.003	0.000
CW	0.000	-0.007	0.031	0.004	-0.023	0.021	0.003	-0.459	0.585	0.011	0.000	0.001
LOI	0.000	0.005	0.017	-0.006	-0.016	0.021	0.008	-0.250	0.347	0.007	0.001	0.001
NPB	0.000	-0.004	0.011	-0.002	-0.007	0.006	0.004	-0.144	0.339	0.005	0.005	-0.001
VL	0.002	0.003	0.007	-0.006	-0.005	0.005	0.003	-0.029	0.334	-0.001	-0.009	0.000
LL	0.000	-0.007	0.030	-0.006	-0.015	0.022	0.002	-0.439	0.550	0.017	0.003	-0.001
LW	0.000	-0.005	0.032	-0.003	-0.019	0.025	0.005	-0.416	0.609	0.014	0.003	-0.002
NOL	0.000	0.001	0.017	-0.003	-0.010	0.007	0.005	-0.196	0.078	0.010	0.006	0.004
PL	0.000	0.003	0.031	-0.001	-0.025	0.027	0.009	-0.413	0.613	0.011	-0.002	0.001
DFFF	0.000	-0.009	-0.007	-0.005	0.009	-0.009	-0.005	0.077	0.016	-0.005	0.005	0.002
NFFF	0.000	0.010	-0.004	0.001	0.000	-0.003	0.002	0.190	-0.175	-0.010	-0.008	0.006

Table 4. Continued.

	FL	FD	FT	SEE	SL	SW	CD	NFP	AFW	SEW	TSS	VC
OL	0.000	-0.007	-0.006	-0.002	0.019	-0.020	-0.001	0.079	-0.168	-0.006	0.002	-0.002
PEDL	-0.001	-0.002	0.003	-0.007	-0.005	0.014	0.005	-0.172	0.192	0.007	0.009	0.002
FL	**0.004**	0.008	0.012	-0.002	-0.007	0.005	0.000	-0.033	0.286	-0.001	-0.005	-0.002
FD	0.001	**0.040**	-0.002	0.002	-0.021	0.024	0.013	0.165	0.090	0.000	-0.006	-0.003
FT	0.001	-0.001	**0.056**	-0.003	-0.020	0.020	0.003	-0.419	0.580	0.010	-0.009	0.006
SEE	0.000	-0.003	0.005	**-0.033**	0.000	0.003	0.005	-0.167	0.070	0.002	0.002	0.001
SL	0.001	0.019	0.024	0.000	**-0.045**	0.041	0.012	-0.335	0.595	0.011	-0.010	0.001
SW	0.000	0.020	0.023	-0.002	-0.039	**0.048**	0.010	-0.287	0.583	0.013	-0.005	-0.002
CD	0.000	0.022	0.006	-0.007	-0.022	0.021	**0.024**	0.065	0.278	0.004	0.004	-0.003
NFP	0.000	0.009	-0.032	0.008	0.021	-0.019	0.002	**0.738**	-0.506	-0.012	0.008	-0.010
AFW	0.001	0.004	0.031	-0.002	-0.026	0.027	0.006	-0.361	**1.034**	0.011	-0.002	0.000
SEW	0.000	0.000	0.022	-0.003	-0.020	0.023	0.003	-0.331	0.431	**0.026**	0.005	-0.001
TSS	0.001	0.007	0.016	0.002	-0.014	0.008	-0.003	-0.190	0.074	-0.004	**-0.031**	0.008
VC	0.000	-0.006	0.017	-0.002	-0.003	-0.004	-0.004	-0.381	-0.020	-0.002	-0.013	**0.019**

Residual are 0.00288

CL-Cotyledon length, CW: Cotyledon width, LOI: Internodal length, NPB: Number of primary branches, VL: Vine length, LL: Leaf length, LW: Leaf width, NOL: Number of lobes, PL: Petiole length , DFFF: Days to first female flower, NFFF: Nodes of first female flower, OL: Ovary length, PEDL: Peduncle length, FL: Fruit length, FD: Fruit diameter, FT: Flesh thickness, SEE: Seediness, SL: Seed length, SW: Seed width, CD: Crop duration, NFP : Number of fruit per plant, AFW: Average fruit weight, SEW: 100 seed weight, TSS: TSS, VC: Ascorbic acid content.

(2007) and Muralidharan *et al*. (2013).

CONCLUSION

The present study has recorded significant agro-morphological variation in the genotypes which shows that there is sufficient variation for selection of suitable genotypes for various production systems. The variability observed in vegetative and reproductive traits could be utilized in variety improvement programs. Traits like cotyledon length, vine length, fruit length, fruit diameter, seed length, seed width, crop duration, number of fruit per plant, avg fruit wt exhibited desirable association with yield/ha should be given more importance for genetic improvement to bring about an increase in overall production of ash gourd through enhanced fruit yield per plant. It would therefore, be rewarding to lay stress on these characters in hybridization program for further improvement of yield and related characters in ash gourd. Future research work should focus on the intercultural management and evaluation of genotypes across a range of environments to identify and select location- specific and widely adaptive genotypes.

ACKNOWLEDGMENT

The authors are thankful to Project coordinator, AICRP (vegetable crops), IIVR, Varanasi for providing research materials and financial assistance.

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