African Journal of Biotechnology Vol. 12(6), pp. 539-543, 6 February, 2013
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB12.2968
ISSN 1684–5315 ©2013 Academic Journals

Full Length Research Paper

Genetic variability, correlation and path analysis in sponge gourd (*Luffa cylindrica* Roem.)

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Accepted 1 February, 2013

The performance, genetic variability, heritability, genetic advance, correlation and path analysis for yield and yield contributing characters namely total yield per vine (kg), number of fruits per vine, average weight of fruit (g), average length of fruit (cm), average diameter of fruit (cm), days to anthesis of first male flower, days to anthesis of first female flower, node number at which first female flower appeared, days to maturity, number of primary branches, vine length (cm), specific gravity (g/cc), number of seeds per fruit and total soluble solids (°Brix) of 20 sponge gourd genotypes were studied. Significant variations were observed for all the characters in all the genotypes used in the experiment. Highest genotypic and phenotypic variations were observed for total yield per vine followed by number of seeds per fruit, average weight of fruit and total soluble solids. Number of seeds per fruit, average weight of fruit and specific gravity showed high heritability with high genetic advance. Total yield per vine was found to be positively and significantly correlated with number of fruits per vine, average weight of fruit and number of seeds per fruit. Path coefficient analysis revealed that average diameter of fruit, number of primary branches, number of fruits per vine, average weight of fruit and total soluble solids showed positive direct effects on total yield per vine. Hence, selection for these traits for improving yield per vine in sponge gourd is suggested.

Key words: Sponge gourd, direct and indirect effects, genotypes, genetic variability, path analysis, heritability, traits.

INTRODUCTION

Cucurbits form an important and big group of vegetable crops and sponge gourd (*Luffa cylindrica* Roem Syn. *Luffa aegyptiaca*) is one of the important members of this group. Sponge gourd has been cultivated for centuries in the Middle East and India, China, Japan and Malaysia (Porterfield, 1955). Sponge gourd is native to Tropical Asia, probably India and South East Asia. The tender fruit is used as vegetable which is easily digestible and increase appetite when consumed (Okusanya et al., 1981). Besides being a vegetable, the mature, dry fruit consists of a hard shell surrounding a stiff, dense network of cellulose fibers (sponge) which is a good source of fiber used in industries for filter and cleaning the motor car, glass wares, kitchen utensil, bath and body bathing accessories (Shah et al., 1980; Oboh and Aluyor, 2009). Matured fibers are generally used in washing ships and decks and manufacturing slippers or baskets and used as shoe mats, inner cloth of bonnet (Lee and Yoo, 2006). The fibrous vascular system inside the fruit after been separated from the skin, flesh and seeds, can be used as a bathroom sponge, as a component of shock absorbers, as a sound proof linings, as a utensils cleaning sponge, as packing materials, for making crafts, as filters in factories and as a part of soles of shoes (Bal et al.,

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Table 1. Name of the genotypes and place of collection.

Genotype	Place	Genotype	Place	Genotype	Place	Genotype	Place
UDSG-1	Banswara	UDSG-6	Aspur	UDSG-11	Kotda	UDSG-16	Gogunda
UDSG-2	Salumber	UDSG-7	Paloda	UDSG-12	Vallabhnagar	UDSG-17	Dhariyawad
UDSG-3	Dungarpur	UDSG-8	Jaisamand	UDSG-13	Mavli	UDSG-18	Kanod
UDSG-4	Sagwada	UDSG-9	Ranakpur	UDSG-14	Pindwara	UDSG-19	Jhalawad
UDSG-5	Kherwada	UDSG-10	Sirohi	UDSG-15	Falna	UDSG-20	Pindwara

UDSG, Udaipur sponge gourd.

2004). They can also be used for cleaning floors or cars without scratching. The small ones are softer and good for washing the face and larger ones for the body. They can also be recycled into mats or pillows when they finally wear down (Newton, 2006). Sponge gourds are also used as absorbent (Altinisik et al., 2010). Sponge gourd struts are characterized by a microcellular architecture with continuous hollow microchannels, which form vascular bundles and yield a multimodal hierarchical pore system (Zamperi et al., 2006). The cellulose content varies from 55 to 90%, the lignin content is within the range of 10 and 23%, and the hemicelluloses content is around 8 and 22% and ash 2.4% (Satyanarayana et al., 2007; Tanobe et al., 2005). Sponge gourd is a highly nutritive vegetable and contains moisture of 93.2 g, protein 1.2 g, fat 0.20 g, carbohydrate 2.9 g, vitamins (thiamin 0.02 mg, riboflavin 0.06 mg, niacin 0.4 mg and carotene 120 mg), minerals (calcium 36 mg, phosphorus 19 mg and ferrous 1.1 mg) and fibers 0.20 g per 100 g of edible portion (Gopalan et al., 1999).

Sponge gourd is an annual climber and monoecious vegetable, but different sex form like hermaphrodite, staminate, pistillate, etc. are commonly found in nature (Takahashi, 1980). There is wide variability in size of fruit; ranging from a few centimeters to one meter, fruit shape and colour as traits are complex and controlled by several genes (Beyer et al., 2002; Zalapa et al., 2006). It is a cross pollinated vegetable, thus, its natural population has tremendous variability for fruit shape, colour, taste etc. Evaluation of genotypes to assess the existing variability is considered as preliminary step in any crop improvement programme. In order to pursue an effective breeding programme, the present investigation was carried out to gather information on genetic variability, heritability, genetic gain, correlation and path analysis for different characteristics of sponge gourd.

MATERIALS AND METHODS

Location of experiment

The genotypes were sown using randomized block design with three replications at Horticulture Farm, Department of Horticulture, Rajasthan College of Agriculture, Udaipur, Rajasthan (India) during July to October, 2010. Each entry was planted in a single row of 3 m long maintaining row to row and plant to plant spacing of 1 m.

Plant material and source

The present investigation comprised 20 genotypes of sponge gourd collected from various parts of Rajasthan state. The details of germplasm are shown in Table 1.

Observations

Observations on five randomly selected plants from each replication were recorded for total yield per vine (kg), number of fruits per vine, average weight of fruit (g), average length of fruit (cm), average diameter of fruit (cm), days to anthesis of first male flower, days to anthesis of first female flower, node number at which first female flower appeared, days to maturity, number of primary branches, vine length (cm), specific gravity, number of seeds per fruit and total soluble solids.

Number of days from sowing to opening of first male flower on a vine was recorded as the number of days required for anthesis of first male flower. The number of days from sowing to the opening of first female flower on a vine was recorded as the number of days require for anthesis of first female flower. Node number at which first female flower appeared was recorded as the number of node on which first female flower appeared. Total number of primary branches of the individual plants was counted at the time of final harvest. Fruit were harvested at horticulture maturity stage. Number of marketable fruits were counted at each picking and summed for all the picking for each plot. Average number of fruits per vine was calculated after dividing total number of fruit by five. Five marketable fruit were randomly selected from each plot of a replication during the picking and length of each fruit was measured in centimeter from head end and up to blossom scar with the help of Vernier calipers. Average fruit length was calculated using arithmetic mean. Total fruit weight of plot was divided by total number of fruits of the plot to get the average weight of fruit. The same fruit which were used for taking observation for average length of fruit was also used for this character. Diameter was recorded from the center position of fruit by Vernier calipers. Specific gravity of the fruit was worked out by dividing the weight of the fruit by the volume of the same fruit and was expressed as gram per cubic centimeter (g/cc). Five fruits were left for maturity on each genotype for recording this observation. At maturity, all seeds from these fruits were extracted and counted. Finally, it was divided by five to get the average number of seeds per fruit. The vine length was measured in centimeter from the ground level to the tip of the main vine at the time of final harvest. Number of days required from the date of sowing to the date of first picking of the marketable fruit(s) of a plot was recorded as days to maturity. Total fruit yield over all the pickings were recorded for each plot and yield per vine was obtained after dividing total yield by number of plants of a plot. Total soluble solids of the fruit were determined by using a hand refractometer of 0 to 30% range. One drop of fruit juice was put on the prism of the refractometer and percent total soluble solids (TSS) was recorded directly. The value were corrected at 20°C and

Table 2. Estimates of genotypic and phenotypic coefficients of variation, heritability and genetic gain of various characters.

Character	GCV (%)	PCV (%)	h^2 (%)	GA	GG (%)
Days to anthesis of first male flower	7.22	7.97	82.08	4.89	13.47
Node number at which first female flower appeared	9.44	10.42	82.12	1.88	17.63
Days to anthesis of first female flower	8.12	8.95	82.35	5.24	15.18
Average length of vine (cm)	9.33	9.53	95.81	93.99	18.82
Days to maturity	10.74	12.10	78.72	1.93	19.63
Number of primary branches	12.71	13.22	92.47	3.22	25.17
Number of fruits per vine	13.40	14.01	91.54	6.72	26.42
Average length of fruit (cm)	15.96	16.44	94.21	7.66	31.90
Average weight of fruit (g)	22.49	22.77	97.60	67.94	45.78
Average diameter of fruit (cm)	9.88	10.72	84.82	1.83	18.74
Number of seeds per fruit	26.90	27.15	98.17	78.68	54.91
Total yield per vine (kg)	29.48	29.92	97.13	2.63	59.86
Specific gravity (g/cc)	17.05	17.26	97.57	0.22	34.69
Total soluble solids (ºBrix)	21.32	22.21	92.17	1.50	42.17

GCV, Genotypic coefficient of variation; PCV, phenotypic coefficient of variation, h^2, heritability; GA, genetic advance, GG, genetic gain.

expressed as percent TSS of the fruit (AOAC, 1960).

Statistical analysis

Genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), broad sense heritability, correlation (genotypic and phenotypic) and path coefficient were computed by the methods suggested by Al-Jibouri et al. (1958) and Dewey and Lu (1959).

RESULTS AND DISCUSSION

The analysis of variance revealed highly significant differences among 20 genotypes of sponge gourd for all the characters studied. Environment play an important role in expression of various characters as the PCV was found to be higher than the corresponding GCV. Maximum range was recorded for total yield per vine (2.67 to 8.30 Kg) followed by number of fruits per vine (20.92to 35.87) and average weight of fruit (106.87 to 216.20 g) indicating more variability in these traits which indicated a greater scope for selection among the existing genotype, whereas minimum range was observed for days to anthesis of first male flower (Table 2).

High values of PCV as well as GCV were recorded for total yield per vine, number of seeds per fruit and average weight of fruit. The high magnitude of GCV further revealed the greater extent of variability presence in the characters, suggesting good scope for improvement through selection of this crop. Similar findings have also been reported by Singh et al. (2002) in ridge gourd and Kutty and Dharmatti (2004) in bitter gourd.

The GCV does not offer full scope to estimate the heritable variation; therefore, estimation of heritability becomes necessary. All the traits expressed high heritability which ranged from 78.72 (days to maturity) to 98.17% (number of seeds per fruit) (Table 2) suggesting the important role of genetic constitution in the expression of the characters and such traits were considered to be dependent from breeding point of view. Out of 14 characters studied, number of seeds per fruit and average weight of fruit showed high heritability coupled with high genetic advance which showed that these two characters had additive gene effect and therefore, they are more reliable for effective selection.

The estimates of genotypic correlation were slightly higher than their corresponding phenotypic correlation for all the characters (Table 3). Total yield per vine exhibited significant and positive correlation with number of fruit per vine, average weight of fruit, number of seeds per fruit and total soluble solids both at genotypic and phenotypic levels (Table 3) indicating that any increase in these four characters would bring about an enhancement in the yield. Further, average weight of fruit was significantly and positively correlated with number of seeds per fruit, total yield per vine, average length of fruit, number of fruits per vine, suggesting thereby, the increase in either of one will ensure the increase in fruit weight.

Path analysis revealed that among 14 traits, few traits namely, average diameter of fruit (5.93), total soluble solids (2.92), number of primary branches (2.46), average weight of fruits (0.97) and number of fruits per vine (0.81) exhibited positive direct effects on fruit yield per vine. Days to maturity (-2.97), number of seeds per fruit (-2.22), node number at which first female flower appeared (-2.17) and days to anthesis of first female flower (-2.16) were found to be negatively associated with total yield per vine but in desirable direction because negative values of these traits are beneficial and contribute positively to the yield per vine (Table 4). The characters,

Table 3. Genotypic (rg) and phenotypic (rp) correlation coefficients between different characters in sponge gourd.

Genotype		X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14
X1	Rg	1.00	0.30	-0.32	0.06	-0.02	0.12	-0.08	-0.36	0.38	-0.12	0.00	-0.08	-0.15	-0.16
	rp	1.00	0.25	-0.26	0.06	-0.07	0.13	-0.08	-0.29	0.34	-0.11	0.01	-0.07	-0.16	-0.16
X2	Rg		1.00	0.35	0.13	-0.07	0.26	0.31	0.30	-0.02	0.49*	0.22	0.38	0.01	-0.07
	rp		1.00	0.34	0.12	-0.03	0.25	0.31	0.26	-0.02	0.48*	0.19	0.37	-0.00	-0.05
X3	Rg			1.00	0.13	-0.29	0.31	-0.12	0.54*	0.00	0.79**	0.46*	0.67**	-0.20	0.38
	rp			1.00	0.12	-0.25	0.30	-0.11	0.51*	0.00	0.77**	0.43	0.66**	-0.17	0.34
X4	Rg				1.00	-0.12	0.53*	-0.32	0.27	0.37	0.13	0.38	0.35	-0.25	0.34
	rp				1.00	-0.11	0.51*	-0.28	0.25	0.35	0.13	0.35	0.34	-0.22	0.29
X5	Rg					1.00	0.05	0.26	-0.10	-0.19	-0.30	0.02	-0.06	0.30	0.20
	rp					1.00	0.04	0.31	-0.09	-0.16	-0.27	0.02	-0.06	0.25	0.16
X6	Rg						1.00	-0.11	0.17	-0.03	0.25	0.39	0.36	-0.26	-0.11
	rp						1.00	-0.10	0.16	-0.02	0.22	0.36	0.33	-0.24	-0.09
X7	Rg							1.00	-0.13	-0.50*	0.14	0.09	-0.08	0.78**	-0.35
	rp							1.00	-0.14	-0.44	0.13	0.06	-0.07	0.66**	-0.28
X8	Rg								1.00	-0.25	0.31	0.13	0.30	-0.36	0.56**
	rp								1.00	-0.23	0.29	0.11	0.29	-0.31	0.50*
X9	Rg									1.00	0.10	0.12	0.20	-0.21	0.33
	rp									1.00	0.10	0.11	0.19	-0.21	0.31
X10	Rg										1.00	0.47*	0.52*	0.12	0.30
	rp										1.00	0.45*	0.51*	0.10	0.27
X11	Rg											1.00	0.78**	0.29	0.30
	rp											1.00	0.73**	0.25	0.25
X12	Rg												1.00	0.13	0.31
	rp												1.00	0.11	0.28
X13	Rg													1.00	-0.10
	rp													1.00	-0.09
X14	Rg														1.00
	rp														1.00

X1, Node number at which first female flower appeared; X2, total soluble solids (ºBrix); X3, average weight of fruit (g); X4, average length of vine (cm); X5, days to maturity; X6, number of primary branches; X7, days to anthesis of first male flower; X8, average length of fruit (cm); X9, specific gravity (g/cc); X10, number of seeds per fruit; X11, number of fruits per vine; X12, total yield per vine (kg); X13, days to anthesis of first female flower; X14, average diameter of fruit (cm).

Table 4. Direct (diagonal) and indirect effect of different correlated characters on total yield per vine.

Character	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	r
X1	**-2.17**	0.87	0.31	-0.09	0.06	0.29	-0.16	1.70	-0.52	0.26	0.00	0.33	-0.97	-0.08
X2	-0.65	**2.92**	-0.34	-0.21	0.22	0.65	0.59	-1.45	0.03	-1.09	0.17	-0.02	-0.43	0.38
X3	0.69	1.03	**0.97**	-0.20	0.86	0.76	-0.23	-2.55	-0.00	-1.76	0.37	0.43	2.25	0.67**
X4	-0.13	0.38	-0.12	**-1.60**	0.35	1.30	-0.61	-1.27	-0.50	-0.30	0.31	0.53	2.01	0.35
X5	0.04	-0.22	0.28	0.19	**-2.97**	0.14	0.50	0.49	0.26	0.67	0.02	-0.64	1.19	-0.06
X6	-0.26	0.77	-0.30	-0.84	-0.16	**2.46**	-0.20	-0.81	0.04	-0.55	0.32	0.56	-0.64	0.36
X7	0.18	0.89	0.12	0.51	-0.77	-0.26	**1.92**	0.64	0.68	-0.30	0.07	-1.69	-2.06	-0.08
X8	0.77	0.89	-0.52	-0.43	0.30	0.42	-0.26	**-4.76**	0.34	-0.68	0.10	0.78	3.33	0.30
X9	-0.82	-0.06	-0.00	-0.59	0.56	-0.07	-0.96	1.19	**-1.36**	-0.23	0.10	0.46	1.98	0.20
X10	0.26	1.43	-0.76	-0.21	0.89	0.61	0.26	-1.47	-0.14	**-2.22**	0.38	-0.25	1.75	0.52*
X11	-0.00	0.63	-0.44	-0.61	-0.06	0.97	0.16	-0.61	-0.17	-1.05	**0.81**	-0.62	1.77	0.78**
X12	0.33	0.03	0.19	0.39	-0.88	-0.63	1.49	1.73	0.29	-0.26	0.23	**-2.16**	-0.62	0.13
X13	0.36	-0.21	-0.37	-0.54	-0.59	-0.27	-0.66	-2.67	-0.46	-0.66	0.24	0.23	**5.93**	0.31

Residual effect = 0.7975; X1 = node number at which first female flower appeared; X2 = total soluble solids (ºBrix); X3 = average weight of fruit (g); X4 = average length of vine (cm); X5 = days to maturity; X6 = number of primary branches; X7 = days to anthesis of first male flower; X8 = average length of fruit (cm); X9 = specific gravity (g/cc); X10 = number of seeds per fruit; X11 = number of fruits per vine; X12 = days to anthesis of first female flower; X13 = average diameter of fruit (cm).

that is, total soluble solids, number of primary branches, days to anthesis of first male flower, average weight of fruit and number of fruit per vine was positively correlated with total yield per vine.

Conclusions

On the basis of this study, it can be concluded that selection would be rewarding for total yield per vine, number of fruits per vine, average weight of fruit, average length of fruit and average diameter of fruit in bringing out the improvement in the sponge gourd because they appeared with high value of GCV, PCV, heritability and genetic gain. Further, correlation study also suggested that for improvement in yield, selection for such a plant having more number of fruits, greater weight of fruit, more length of fruit and more diameter of fruit would be beneficial. Number of fruit and length of fruit were found to be the important characters for increasing the yield potential in sponge gourd. Among the genotypes, UDSG-1 (8.30 kg), UDSG-5 (5.46 kg) and UDSG-4 (5.40 kg) were found to be higher in total yield per vine, which could be gainfully utilized in further breeding/improvement programme.

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