Correlation Co-Efficient and Path Co-Efficient Analyses for Grain Yield and Its Related Traits in Guar (*Cyamopsis Tetragonoloba* L.) Lines

Author's Details:

Muhammad Shakir[1]*, Humera Razzaq[2], Lal Hussain Akhtar[3], Qasim Farooq[1], Hina Saleem[2], Aisha Sodagar[1], Tooba Zafar[1]

[1] Department of Botany, University of Agriculture, University Main Road, Faisalabad, Punjab 38000, Pakistan [2] Department of Plant Breeding and Genetics, University of Agriculture, University Main Road, Faisalabad, Punjab 38000, Pakistan [3] Agricultural Research Station, Bahawalpur, Pakistan

*Corresponding Author Email: shakirkhan1418@gmail.com

Abstract

In the present study evaluation of twenty-eight cluster bean lines were done at research area of Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, Pakistan. The research trial was conducted in RCBD with three replications during kharif- 2019. Genotypic and phenotypic correlation between the characters and their direct and indirect effect were estimated. Significant correlations at both genotypic and phenotypic level was observed in days to flowering, days to pods formation, days to 50% maturity, plant height, branches/plant, clusters/plant, pods/plant, pod length, days to harvesting, 100-seed weight indicated positive correlation with pods per plant (0.012), pod length (0.168), grains/pod (0.168), cluster/plant (0.014), grain yield/plant (0.072) and galactomannan content (0.072) at phenotypic and genotypic level. Seed yield/plant revealed positive correlation with plant height (0.414), cluster/plant (0.602), pod/plant (0.806), pod length (0.532), grains per pod (0.412), 100 grain weight (0.072) and protein content (0.137) at phenotypic and genotypic level. Whereas data were subjected to path analysis revealed that days to flowering, days to pod formation, clusters/plant, pods/plant, grains/pod and galactomannan content had direct positive effect on seed yield/plant demonstrated that these were the main contributing characters to yield/plant.

Keywords: *Guar [(Cyamopsis tetragonoloba (L.)], Genotypic correlation, Phenotypic correlation, Path analysis*

Introduction

The crop cluster bean (*Cyamopsis tetragonoloba* L.) well-known as guar in Pakistan is leguminous crop, becomes more prevalent due to its great medicinal and nutritious properties. It is domesticated as a minor crop in various parts of tropical territories of the country. It was probably domesticated in dry territories of West Africa and the Arabian dealers are thought to have introduced the guar to Asia through South India (Smith, 1976). It is extensively cultivated in Pakistan and India and also cultivated in some other countries like Malaysia and other regions of South eastern and Southern Asia as a fodder and vegetable reap.

Guar is a short day, bushy or erect annual crop belongs to family Fabaceae and it is an open-pollinated crop (Purseglove, 1981). It is an important potential crop cultivated for its pods, for gum in its endosperm (30-35%) and for it use as vegetable. Besides extraction of gum its pods are widely used as cattle feed due to its nutritious properties. Kumar and Singh (2002) reported that its pods are enriched with iron (4.5 mg), carbohydrate (10.8 g), moisture (81 %), vitamin A (65.3 IU), fat (1.4 g), vitamin C (49 mg), protein (3.2 g), energy (16 Kcal), calcium (57 mg) and edible portion.

Currently, cluster bean is cultivated as a grain crop because of its more use in industrial level. Guar is the major source of galactomannan gum which is important industrial product (Jackson and Doughton, 1982). Galactomannan or guar gum is the polysaccharide present in the seed endosperm of cluster bean (Whistler and Hymowitz, (1979).

Lately, the guar gum use increased in oil industries for hydraulic cracking (Gresta *et al*. 2013). It is also used in natural gas extraction process which increase the viscosity and efficiency (King, 2008). The demand for guar gum from foreign countries increased due to its greater use in oil fracking (Gresta *et al*. 2013). USA is major buyer and importer of guar gum. Presently, the USA has almost (1.7 M) natural gas sources comprising round 61,000 wells present in Mexico (Kelso, 2015). To frack one well about nine tons of gum is needed, for this purpose about eighty acres of guar cultivation is required (Trostle, 2013).

Genetic variability is an important tool in plant breeding. Presence of it, is a first step in development of any variety. Correlation measures association between traits and indicates component character on which selection is made for improvement. Path analysis, on other hand is an immensely powerful statistical application that determines interrelationship among variables/yield components and indicates weather it is influenced directly or indirectly, and partitions correlation into direct and indirect effects. Thus the core objective of current research was to assess the genomic analysis correlation and path analyses among various accessions of guar.

Materials and Methods

Twenty-eight guar accessions namely S-3517, S-3545, S-5617, S-5823, S-5885, S-6000, S-6251, S-6260, S-6484, S-6494, S-6497, S-6498, S-6501, S-6514, S-6520, S-6524, S-6525, S-6526, S-6528, S-6530, S-6558, S-6565, S-6566, S-22278, S-28700, BR-90, BR-99, BR-2017 were evaluated in this study. The field trial was laid out under RCBD having three repeats in the field of Plant Breeding and Genetics, Department, University of Agriculture, Faisalabad as shown in Fig. 1. To prepare seed bed, 10 seeds/accession. Sowing were done with the help of hand drill during May, 2019. Pre-sowing irrigation was also done in field with plot size of 336 m^2. Row length was 3.2 m, path in between the beds was 1.22 m, distance from row to row was kept 84 cm, distance from one plant to other was 27 cm and distance between boundary wall and plant was 45 cm.

Total three numbers of irrigations were applied. Cultural practices were performed at time when needed in all the experimental units evenly. At different stages of crop fertilizers were used to maintain growth. DAP were used at the time of sowing. One more bag of urea was applied at the time of flowering. To protect the crop from different disease four time, spray of different chemicals was applied. First spray of "Topsin-M" was done to protect plants from wilting due to fungicides and pesticides attack. Second spray of "PolytrinC" was applied to protect plants from insects' attack. Third spray of "Plant Protector" 100ml/20L obtained from Soil Fertility Lab were sprayed to minimize virus attack and the last spray of "Hathora" were applied for the attack of white fly. At maturity data were noted on plant height (cm), days to flowering, days to pods formation, days to 50% maturity, branches per plant, clusters $plant^{-1}$, days to harvesting, pods $plant^{-1}$, length of pod (cm), grains pod^{-1} (g), 100-grain weight (g), grains harvest $plant^{-1}$ (g) and oil, protein and galactomannan content (%).

Recorded data will be submitted to correlation coefficient analyses (Miller *et al.,* 1958) and path coefficient analyses (Dewey and Lu, 1959).

Results and discussions

Correlation Co-Efficient Analysis

The studies regarding correlation coefficient analyses on yield of vegetable pod and its yield attributed traits. The results of the correlation coefficient for different pod yield characters of cluster bean are presented in (Table 1&2). Pods/plant showed positive correlation with plant height (0.448), clusters per plant (0.731), pod length (0.639), grains per pod (0.429), grain yield per plant (0.806) and protein content at both phenotypic extent and revealed positive correlation with plant height (0.739), clusters/plant (0.870), pod length (0.804), grains per pod (0.643) and protein content at genotypic level which indicate strong association with these traits, yield can easily be increased by suggesting better selection for these traits will be helpful in improving vegetal pod yield. Plant height positive correlation with pod length (0.700) grains per pod (0.310), cluster/plant (0.777), grains yield per plant (0.800) and pods/plant (0.739) at genotypic extent and pod length (0.290) grains per pod (0.999), clusters/plant (0.484), grains yield per plant (0.414), pods/plant (0.448) and protein content (0.304) at phenotypic level. 100-seed weight showed positive correlation with pods per plant (0.012), pod length (0.168), grains per pod (0.168), cluster per plant (0.014), grain yield per plant (0.072) and galactomannan content (0.072) at phenotypic extent and pods per plant (0.012), pod length (0.168), grains yield per plant (0.110), cluster per plant (0.011), grains per pod (0.110) and galactomannan content (0.073) at genotypic level. Pod length (cm) revealed positive with plant height (0.700), clusters per plant (0.655), grains per pod (0.539), grain yield per plant (0.691) and pods per plant (0.804) at genotypic level and positive with plant height (0.290), clusters per plant (0.416), grains per pod (0.613), grain yield per plant (0.532) and pods per plant (0.639) at phenotypic level. Seed yield/ plant (g) showed positive correlation with plant height (0.414), cluster/plant (0.602), pod/plant (0.806), pod length (0.532), grains per pod (0.412),100 seed weight (0.072) and protein content (0.137) at phenotypic extent and

plant height (0.800), cluster/plant (1.006), pod/plant (1.033), pod length (0.691), grains per pod (0.551), 100 seed weight (0.11) and protein content (0.215) at genotypic level. Cluster per plant positive correlation with plant height (0.77), pods per plant (0.870), pod length (0.655), grains per pod (0.435), 100-seed weight (0.014) and grain yield per plant (1.006) at genotypic level and plant height (0.484), pods per plant (0.0731), pod length (0.461), grains per pod (0.380), 100-seed weight (0.011) and grain yield per plant (0.602) at phenotypic level which revealed strong relationship with these characters with seed yield per plant. The same results were found with earlier investigation in guar by Girish *et al.*, (2012) clusters per plant, pods per plant and hundred grains weight and Rakesh *et al*., (2011) for seeds per pod in cow pea.

Path Co-Efficient Analysis

To identify the direct and indirect effect of various parameters on dependent variable (seed yield/plant) path analyses was performed and the other characters as independent variables. Days to flowering had positive and direct effect on grain yield/plant. This results are related with the investigation of Ramaprasad *et al*. (2007) in French bean and Ibrahim *et al*. (2012) in guar for the above characters. Days to pods formation had positive and direct effect on grain yield per plant. Days to 50% maturity had negative and direct effect on grain yield per plant. Plant height had negative and direct effect on grain yield/plant. Branches per plant had negative and direct effect on grain yield per plant. The same results were repoted by Ramesh and Tewatia (2002) and Shridhar (2005) in peas and Ibrahim *et al*. (2012) in cluster bean for the above characters. Plant height showed insignificant negative direct effect (-0.0001G) on pod yield per plant at genotypic level. The results are similar with Manivannan and Anandakumar (2013) findings.

Clusters/plant had positive and direct effect on grain yield/plant. Pods/plant had positive and direct effect on grain yield per plant. Pod length had negative and direct effect on grain yield per plant. Sime results were revealed by Rakesh *et al*. (2011) in cluster bean and Vidya and Sunny (2002) in yard-long bean. Similar results were found by Shridhar (2005) in peas and Ramaprasad *et al*. (2007) in French bean, Ibrahim *et al*. (2012) in cluster bean. Grains/pod had positive and direct effect on grain yield/plant. These findings in promise with Baswana *et al*. (1980) and Biju *et al*. (2001) in Indian bean and Rai *et al*. (2004) in French bean. Days to harvesting had negative and direct effect on grain yield/plant. 100-grains weight had negative and direct effect on grain yield/plant. Similar results were observed by Brindha *et al*. (1995), Shabarishrai and Dharmatti (2014) in cluster bean. Oil content had negative and direct effect on grain yield/plant. Protein content had negative and direct effect on grain yield/plant. The result is in line with the results of Ramesh and Tewatia (2002) and Shridhar (2005) in peas, Ramaprasad *et al*. (2007) in French bean, Ibrahim *et al*. (2012) in cluster bean for the above characters. At phenotypic level, this character showed negligible positive direct effect (0.0002P) on pod yield per plant. Galactomannan content had positive and direct effect on grain yield per plant. Similar results were observed by Henry *et al*. (1986), Brindha *et al*. (1995) and Shabarishrai and Dharmatti (2014) in cluster bean. Gum content recorded negligible negative direct effect on pod yield per plant (-0.0001G) at genotypic level. At phenotypic level, it showed negligible negative direct effect (-0.0002P) on pod yield per plant.

Conclusion

The analyses of correlation has shown that at genotypic and phenotypic extent, days to flowering, days to 50% maturity, branches plant^{-1}, plant height, clusters plant^{-1}, length of pod, pods plant^{-1}, seeds plant^{-1}, days to pods formation, days to harvesting, 100-seed weight, seed yield, oil content, protein content and galactomannan content showed both positive highly significant correlation and negative highly significant correlation. The days to maturity, number of pods per cluster, pod yield and seed yield per plant were very important performance components, as shown by the path co-efficient analysis. These components were positively correlated with each other and by yield as well as suggesting enhancements of yield potential and development of new cultivars of guar in these characters might be easy.

Acknowledgement

The authors are very grateful to Agricultural Research Station, Bahawalpur, Pakistan for providing germplasm source and Department of Plant Breeding and Genetics for providing the essential materials to carry out the research.

Table 1. Genotypic Correlation coefficient of quantitative and qualitative traits in Guar lines

	DF	DPF	DFM	PH	BPP	CPP	PPP	PL	GPP	DH	100-GW	GYP	OC	PC
DPF	0.997**													
DFM	0.965**	0.956**												
PH	-0.758**	-0.782**	-0.806**											
BPP	0.866**	0.873**	0.880**	-0.614**										
CPP	-0.918**	-0.935**	-0.804**	0.777**	-0.626**									
PPP	-0.982**	-0.997**	-0.892**	0.739**	-0.808**	0.870**								
PL	-0.762**	-0.798**	-0.728**	0.700**	-0.650**	0.655**	0.804**							
GPP	-0.442**	-0.495**	-0.321	0.310**	-0.352**	0.435**	0.643**	0.539**						
DH	0.997**	1.000	0.956	-0.782**	0.873**	-0.935**	-0.997**	-0.798	-0.495*					
100-GW	-0.284**	-0.251*	-0.391	-0.086	-0.451	0.014	0.012	0.168	0.168	-0.251*				
GYP	-1.015	-1.033	-0.875**	0.800**	-0.821	1.006	1.033	0.691**	0.551**	-1.033	0.110			
OC	-0.008	-0.022	-0.043	-0.172	0.062	-0.032	-0.003	0.169	0.365**	-0.022	-0.038	-0.062		
PC	-0.320**	-0.354**	-0.261*	0.426	-0.317*	0.265*	0.263*	-0.099	-0.273*	-0.354**	-0.132	0.215*	-0.179	
GC	0.298**	0.312**	0.363**	-0.181	0.069	-0.064	-0.259*	-0.512**	-0.014	0.312*	0.073	-0.092	-0.144	-0.046

DF = Days to Flowering, **DPF** = Days to pod formation, **DFM** = Days to fifty percent maturity, **PH** = Plant Height, **BPP** = Branches per plant, **CPP** = Clusters per plant, **PPP** = Pods per plant, **PL** = Pod Length, **GPP** = Grains per pod, **DH** = Days to harvesting, **100-GW** = 100 Grain weight, **GYP** = Grain Yield per plant, **OC** = Oil content, **PC** = Protein content, **GC** = Galactomannan content

Table 2. Phenotypic Correlation coefficient of quantitative and qualitative traits in Guar lines

	DF	DPF	DFM	PH	BPP	CPP	PPP	PL	GPP	DH	100-GW	GYP	OC	PC
DPF	0.991**													
DFM	0.929**	0.910**												
PH	-0.544**	-0.558**	-0.478**											
BPP	0.610**	0.608**	0.591**	-0.324**										
CPP	-0.579**	-0.591**	-0.516**	0.484**	-0.361**									
PPP	-0.675**	-0.682**	-0.584**	0.448**	-0.561**	0.731**								
PL	-0.437**	-0.459**	-0.453**	0.290**	-0.380**	0.461**	0.639**							
GPP	-0.258*	-0.275*	-0.267*	0.099	-0.187	0.380**	0.429**	0.613**						
DH	0.991**	1.000**	0.910**	-0.558**	0.608**	-0.591**	-0.682**	-0.459*	-0.275*					
100-GW	-0.236*	-0.211*	-0.317*	-0.050	-0.362**	0.011	0.009	0.105	0.083	-0.211*				
GYP	-0.659**	-0.657**	-0.570**	0.414**	-0.500**	0.602**	0.806**	0.532**	0.412**	-0.657**	0.072			
OC	-0.007	-0.019	-0.035	-0.123	0.050	-0.024	-0.002	0.100	0.180	-0.019	-0.038	-0.039		
PC	-0.267*	-0.299*	-0.210*	0.304*	-0.253*	0.202	0.203	-0.062	-0.138	-0.299**	-0.132	0.137	-0.179	
GC	0.254*	0.268*	0.298*	-0.132	0.057	-0.047	-0.200	-0.302*	-0.006	0.268*	0.072	-0.060	-0.144	-0.046

DF = Days to Flowering, **DPF** = Days to pod formation, **DFM** = Days to fifty percent maturity, **PH** = Plant Height, **BPP** = Branches per plant, **CPP** = Clusters per plant, **PPP** = Pods per plant, **PL** = Pod Length, **GPP** = Grains per pod, **DH** = Days to harvesting, **100-GW** = 100 Grain weight, **GYP** = Grain Yield per plant, **OC** = Oil content, **PC** = Protein content, **GC** = Galactomannan content

Table 3. Direct (Diagonal) and indirect effect path coefficients

	DF	DPF	DFM	PH	BPP	CPP	PPP	PL	GPP	DH	100-GW	OC	PC	GC
DF	**1.7419**	0.7912	-0.8994	0.3632	-0.2215	-0.8244	-0.2446	0.0901	-0.0844	-1.8100	0.0611	0.0017	0.0123	0.0074
DPF	1.7368	**0.7936**	-0.8913	0.3746	-0.2233	-0.8401	-0.2485	0.0944	-0.0943	-1.8153	0.0540	0.0047	0.0136	0.0077
DFM	1.6805	0.7587	**-0.9322**	0.3859	-0.2251	-0.7219	-0.2223	0.0861	-0.0612	-1.7356	0.0842	0.0089	0.0101	0.0090
PH	-1.3207	-0.6207	0.7511	**-0.4790**	0.1571	0.6980	0.1842	-0.0828	0.0591	1.4198	0.0184	0.0360	-0.0164	-0.0045
BPP	1.5080	0.6925	-0.8202	0.2941	**-0.2559**	-0.5621	-0.2014	0.0769	-0.0671	-1.5841	0.0971	-0.0130	0.0122	0.0017
CPP	-1.5988	-0.7423	0.7492	-0.3722	0.1601	**0.8982**	0.2167	-0.0775	0.0829	1.6980	-0.0030	0.0066	-0.0102	-0.0016
PPP	-1.7098	-0.7913	0.8317	-0.3540	0.2068	0.7812	**0.2492**	-0.0951	0.1226	1.8100	-0.0025	0.0006	-0.0101	-0.0064
PL	-1.3273	-0.6334	0.6788	-0.3353	0.1664	0.5885	0.2004	**-0.1183**	0.1028	1.4490	-0.0362	-0.0354	0.0038	-0.0126
GPP	-0.7707	-0.3926	0.2993	-0.1486	0.0901	0.3903	0.1602	-0.0638	**0.1907**	0.8980	-0.0362	-0.0764	0.0105	-0.0004
DH	1.7368	0.7936	-0.8913	0.3746	-0.2233	-0.8401	-0.2485	0.0944	-0.0943	**-1.8153**	0.0540	0.0047	0.0136	0.0077
100-GW	-0.4949	-0.1992	0.3649	0.0410	0.1155	0.0124	0.0029	-0.0199	0.0321	0.4558	**-0.2151**	0.0080	0.0051	0.0018
OC	-0.0140	-0.0178	0.0398	0.0823	-0.0159	-0.0284	-0.0008	-0.0200	0.0696	0.0408	0.0083	**-0.2093**	0.0069	-0.0036
PC	-0.5568	-0.2810	0.2436	-0.2041	0.0811	0.2376	0.0655	0.0117	-0.0520	0.6428	0.0285	0.0375	**-0.0385**	-0.0011
GC	0.5192	0.2474	-0.3383	0.0865	-0.0177	-0.0576	-0.0646	0.0605	-0.0028	-0.5660	-0.0156	0.0301	0.0018	**0.0247**

DF = Days to Flowering, **DPF** = Days to pod formation, **DFM** = Days to fifty percent maturity, **PH** = Plant Height, **BPP** = Branches per plant, **CPP** = Clusters per plant, **PPP** = Pods per plant, **PL** = Pod Length, **GPP** = Grains per pod, **DH** = Days to harvesting, **100-GW** = 100 Grain weight, **GYP** = Grain Yield per plant, **OC** = Oil content, **PC** = Protein content, **GC** = Galactomannan content

References

i. *Baswana, K.S., M.L. Pandita, B.S. Dhankhar and P.S. Pratap. 1980. Genetic variability and heritability studies on Indian bean (Dolichos lablab var. lignosus F.). Haryana J. Hort. Sci. 9: 52-55.*

ii. *Biju, M.G., K.P. Prasanna and S. Rajan. 2001. Genetic divergence in hyacinth bean. Veg. Sci. 28: 163-64.*

iii. *Brindha, S., V. Ponnuswami and S. Thamburaj. 1995. Path coefficient analysis in cluster bean. South Indian Hortic. 43: 131-133.*

iv. *Dewy, D.R. and K.H. Lu. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. Agron. J. 51: 515-518.*

v. *Gresta, F., Luca, A.D., Strano, A., Falcone, G., Santonoceto, C., Anastasi, U. and Gulisano, G. (2014) Economic and Environmental Sustainability Analysis of Guar (Cyamopsis tetragonoloba L.) Farming Process in a Mediterranean Area: Two Case Studies. Italian Journal of Agronomy, 9, 20-24.*

vi. *Girish, M. H., V.D. Gasti., N. Thammaiah, M.G. Kerutagi, R. Mulge, T. Shantappa and A.B. Mastiholi. (2012). Genetic divergence studies in cluster bean genotypes [Cyamopsis tetragonoloba (L.) Taub.]. Karnataka J. of Agric. Sci. 25: 14-22.*

vii. *Gresta, F., Sortino, O., Santonoceto, C., Issi, L., Formantici, C. and Galante, Y. (2013) Effects of Sowing Times on Seed Yield, Protein and Galactomannans Content of Four Varieties of Guar (Cyamopsis tetragonoloba L.) in a Mediterranean Environment. Industrial Crops and Products, 41, 46-52.*

viii. *Ibrahim, A.E., H.A. Wahab, A. Mohammed, E.A. Rahman and M. Ahmed. 2012. Path coefficient and selection indices in sixteen guar (Cyamopsis tetragonoloba L.) genotypes under rain-fed. Int. J. Agri. For. 2: 79-83.*

ix. *Jackson, K.J. and Doughton, J.A. (1982) Guar: A Potential Industrial Crop for Dry Tropics of Australia. Journal of the Australian Institute of Agricultural Science, 42, 17-31.*

x. *Kelso, M. (2015) 1.7 Millions Wells in the US—A 2015 Update. FracTracker Alliance.*

xi. *King, H. (2008) Guar Beans and Hydraulic Fracturing.*

xii. *Kumar, D. and Singh. N. B (2002). Guar in India. Scientific Publishers (India). Jodhpur.*

xiii. *Manivannan, A. and C.R. Anandakumar. 2013. Genetic variability, character association and path analysis in cluster bean. J. Food Legumes 26: 34-37.*

xiv. *Miller, P. A., C. Willams, H. F. Robiwson and R. E. Comstock. 1958. Estimates of genotypeic and environmental variance and covariance and their implication in section. Agron. J. 50: 126-131.*

xv. *Purseglove, J.W. (1981). Leguminosae. In Tropical Crops: Dicotyledons. Longman Group Ltd., Essex, U.K. 250–254.*

xvi. *Rai, N., B.S. Asati, D.S. Yadav and A.K. Singh. 2004. Genetic analysis in French bean (Phaseolus vulgaris L.). Veg. Sci. 31: 138-141.*

xvii. *Rakesh, P., S. Manjit and A. Henry. 2011. Stability, correlation and path analysis for seed yield and yield-attributing traits in clusterbean (Cyamopsis tetragonoloba). Indian J. Agric. Sci. 81: 309-313.*

xviii. *Ramaprasad, E., P.G.M. Rao, P.V.R Rama Kumar V.S. Rao. 2007. Character association and path analysis in french bean (Phaseolus vulgaris L.) Andhra Agric. J. 54: 28-30.*

xix. *Ramesh, C. and A.S. Tewatia. 2002. Character association and path analysis studies in Garden pea (Pisum sativum L.). Haryana J. Horti. Sci. 31: 94-97.*

xx. *Shabarishrai, P. and P.R. Dharmatti. 2014. Correlation and path analysis for cluster bean vegetable pod yield. The Bioscan. 9: 811-814.*

xxi. *Shridhar. 2005. Association and path analysis of yield components in garden pea under mid Himalayas. Prog. Hort. 37: 285-288.*

xxii. *Smith, P. G. 1976. Evolution of crop plants, (Ed. N. W. Simmonds). Longman, London and Newyork. 311-312.*

xxiii. *Trostle, C. (2013) Guar in West Texas. Texas A&M AgriLife Extension.*

xxiv. *Vidya, C. and K.O. Sunny. 2002. Correlation and path analysis in yard-long bean. J. Tropical Agric. 40: 48-50.*

xxv. Whisller, R.L. and T. Hymowitz. 1979. Guar agronomy, production, industrial use and nutrition. Purdue Univ. Purdue, West Lafayette, Indiana, 9-124.