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Path analysis for growth, quality, yield and yield components in yardlong bean (*Vigna unguiculata* (L.) Walp. ssp. *sesquipedalis* verdc

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Abstract
The present investigation was conducted on yardlong bean to identify the characters which mainly contribute to the pod yield. Twenty four genotypes of yardlong bean were evaluated during *kharif*, 2017 and observations were recorded on growth, pod yield and quality parameters. Path analysis study revealed that number of primary branches per plant (1.2042 G) and days to 50 % flowering (1.0309 G) showed very high positive direct effect on pod yield per plant at genotypic level and number of nodes per plant (0.4670 G) and protein content (0.3143 G) showed high positive direct effect on pod yield per plant at genotypic level.

Keywords: Yardlong bean, growth, quality, yield and path analysis

Introduction
Yardlong bean (*Vigna unguiculata* (L.) walp. ssp. *sesquipedalis* verdc. 2n=22) belonging to the family leguminaceae is cultivated mainly for its crisp and tender green pods which are consumed both fresh as well as in cooked form. It is also called as asparagus bean, Chinese long bean, pea bean, string bean, snake bean, snake pea, snap pea, bodi and borboti. Yardlong beans, as the name suggests, differ from cowpea in their very slender long green beans, which have a beautiful delicate flavour. This legume is also known as poor man's meat as it is a rich and inexpensive source of vegetable protein along with vitamin A, thiamin, riboflavin, calcium, phosphorus, sodium, potassium, magnesium, vitamin C and micronutrients like iron, zinc, manganese and cobalt (Ano and Ubochi, 2008) [1].

The path coefficient analysis helps in estimating direct and indirect contribution of various components in building up the correlation towards yield. To provide basis for selection and yield improvement in yardlong bean the present investigation was undertaken to determine the degree of association among characters and to measure direct and indirect effects of various component characters on pod yield.

Material and methods
The present investigation entitled "Studies on genetic variability in yardlong bean (*Vigna unguiculata* (L.) Walp. Ssp. *sesquipedalis* verdc.) was conducted during *kharif*, 2017-18 at College of Horticulture, Venkataramannagudem. Twenty four genotypes of yardlong bean collected from various places were sown in Randomized Block Design with 3 replications. Each genotype of a replication consists of eight plants, sown in two rows with a spacing of 2m between the rows and 1m between the plants. All the package of practices were followed as per the recommendation. Data pertaining to the characters such as vine length (cm), number of primary branches per plant, number of nodes per plant, terminal leaf breadth (cm), terminal leaf length (cm), days to first flowering, days to 50% flowering, days to first harvest, length of harvesting period, pod length (cm), pod girth (mm), number of clusters per plant, length of cluster stalk, number of pods per cluster, number of pods per plant, seed number per pod, ascorbic acid content (mg/100g), TSS (°Brix), protein content (mg/100g), titrable acidity (%), 100 seed weight, pod yield per plant (kg), pod yield per plot (kg) and pod yield per hectare (tonnes) were collected from 5 randomly selected plants from each plot in each replication and subjected to path coefficient analysis suggested by Wright (1921), Dewey and Lu (1959) to know the direct and indirect effect of the morphological traits on yield.

Results and Discussion
The association of pod yield with other characters was estimated by path coefficient analysis (Table 1). Number of primary branches per plant (1.2042 G) and days to 50 % flowering (1.0309 G) showed very high positive direct effect on pod yield per plant at genotypic level. Number of nodes per plant (0.4670 G) and protein content (0.3143 G) showed high positive direct effect on pod yield

Table 1: Direct and indirect effects of various yield and yield attributes on pod yield in twenty four genotypes of yardlong bean at phenotypic (P) and genotypic (G) levels

Character		VL	NPB	TLB	TLL	NN	DFF	D50	DFH	LHP	PL	PG	NCP	CSL	NPC	NPP	NSP	AAC	TSS	PC	TA	SW
VL	P	-0.0277	-0.0092	-0.0096	-0.0123	-0.0200	-0.0037	-0.0018	0.0042	0.0021	-0.0116	-0.0125	-0.0125	-0.0068	-0.0131	-0.0114	-0.0045	-0.0049	0.0027	-0.0025	0.0032	-0.0137
	G	-0.0147	-0.0054	-0.0065	-0.0093	-0.0139	-0.0029	-0.0018	0.0034	0.0021	-0.0069	-0.0076	-0.0072	-0.0072	-0.0077	-0.0075	-0.0023	-0.0029	0.0014	-0.0015	0.0026	-0.0081
NPB	P	-0.0173	-0.0518	0.0020	-0.0041	-0.0120	-0.0046	-0.0012	0.0108	-0.0329	-0.0321	-0.0434	-0.0459	-0.0363	-0.0405	-0.0419	-0.0113	-0.0010	-0.0077	0.0013	-0.0047	-0.0253
	G	0.4388	1.2042	-0.0255	0.2525	0.3733	0.2266	0.0962	-0.3023	1.1722	0.8042	1.1305	1.1841	1.2300	1.1087	1.2576	0.5232	0.0201	0.2076	-0.0475	0.1599	0.6191
TLB	P	-0.0331	0.0038	-0.0958	-0.0773	-0.0423	-0.0206	-0.0239	-0.0108	0.0207	-0.0102	0.0018	0.0019	0.0016	0.0042	-0.0029	0.0005	-0.0171	0.0034	-0.0036	-0.0051	-0.0039
	G	-0.3324	0.0158	-0.7480	-0.6707	-0.4463	-0.2383	-0.2878	-0.1182	0.2800	-0.0870	0.0558	0.0049	-0.0632	0.0322	0.0557	-0.1110	-0.1587	-0.0409	-0.0262	-0.0046	-0.0190
TLL	P	0.0456	0.0082	0.0829	0.1028	0.0429	0.0221	0.0207	0.0087	-0.0116	0.0100	0.0181	0.0139	0.0035	0.0139	0.0161	0.0262	0.0116	0.0052	0.0076	0.0021	0.0089
	G	0.1799	0.0597	0.2553	0.2848	0.2205	0.0766	0.0800	0.0466	-0.0790	0.0466	0.0516	0.0543	0.0833	0.0566	0.0444	0.1474	0.0510	0.0221	0.0290	-0.0236	0.0382
NN	P	-0.0094	-0.0030	-0.0058	-0.0055	-0.0131	-0.0014	-0.0006	0.0021	0.0018	-0.0057	-0.0050	-0.0046	-0.0037	-0.0047	-0.0043	-0.0008	-0.0051	0.0011	-0.0016	0.0008	-0.0060
	G	0.4412	0.1448	0.2787	0.3616	0.4670	0.0566	0.0108	-0.1773	-0.0661	0.2431	0.2161	0.2022	0.1790	0.2266	0.2095	0.0978	0.2095	-0.0093	0.0651	-0.0563	0.2750
DFF	P	0.0042	0.0028	0.0068	0.0068	0.0034	0.0315	0.0298	0.0234	-0.0016	0.0049	0.0056	0.0057	0.0029	0.0039	0.0057	-0.0025	0.0068	-0.0027	-0.0088	0.0021	0.0049
	G	-0.0718	-0.0674	-0.1141	-0.0964	-0.0434	-0.3581	-0.3453	-0.2753	-0.0133	-0.0727	-0.0954	-0.0838	-0.1230	-0.1057	-0.0794	0.1636	-0.1073	0.0792	0.1604	0.0014	-0.0748
D50	P	-0.0015	-0.0005	-0.0059	-0.0047	-0.0011	-0.0222	-0.0235	-0.0182	0.0019	-0.0018	-0.0018	-0.0020	-0.0013	0.0001	-0.0024	0.0021	-0.0046	0.0020	0.0070	-0.0027	-0.0023
	G	0.1259	0.0824	0.3966	0.2897	0.0239	0.9940	1.0309	0.8528	-0.0620	0.0864	0.0989	0.1224	0.2702	0.1300	0.0710	-0.4381	0.2962	-0.2562	-0.5080	0.0589	0.1445
DFH	P	0.0028	0.0039	-0.0021	-0.0016	0.0030	-0.0138	-0.0143	-0.0185	0.0021	0.0012	0.0023	0.0027	0.0029	0.0040	0.0018	0.0005	-0.0018	0.0008	0.0058	0.0009	0.0021
	G	0.0818	0.0881	-0.0555	-0.0574	0.1333	-0.2699	-0.2904	-0.3511	0.0509	0.0551	0.0747	0.0801	0.0443	0.0761	0.1066	0.1444	-0.0365	0.0590	0.1879	0.0424	0.0573
LHP	P	0.0046	-0.0386	0.0132	0.0069	0.0083	0.0030	0.0050	0.0070	-0.0609	-0.0264	-0.0351	-0.0368	-0.0275	-0.0401	-0.0370	0.0022	0.0026	-0.0066	0.0003	-0.0092	-0.0121
	G	0.0818	0.0881	-0.0555	-0.0574	0.1333	-0.2699	-0.2904	-0.3511	0.0509	0.0551	0.0747	0.0801	0.0443	0.0761	0.1066	0.1444	-0.0365	0.0590	0.1879	0.0424	0.0573
PL	P	0.0069	0.0102	0.0018	0.0016	0.0072	0.0026	0.0013	-0.0011	0.0071	0.0165	0.0112	0.0120	0.0090	0.0109	0.0112	-0.0016	0.0064	0.0000	0.0012	-0.0001	0.0118
	G	0.1371	0.1950	0.0340	0.0477	0.1520	0.0592	0.0245	-0.0458	0.1750	0.2920	0.2249	0.2323	0.2511	0.2153	0.2383	-0.0245	0.1176	-0.0011	0.0242	-0.0095	0.2194
PG	P	-0.0264	-0.0490	0.0011	-0.0103	-0.0225	-0.0104	-0.0045	0.0073	-0.0337	-0.0399	-0.0585	-0.0528	-0.0371	-0.0508	-0.0478	-0.0092	-0.0130	-0.0058	-0.0035	0.0036	-0.0316
	G	0.0473	0.0856	-0.0068	0.0165	0.0422	0.0243	0.0087	-0.0194	0.0795	0.0703	0.0912	0.0912	0.1002	0.0929	0.0986	0.0271	0.0197	0.0156	0.0050	-0.0017	0.0566
NCP	P	0.0378	0.0745	-0.0016	0.0113	0.0298	0.0151	0.0072	-0.0123	0.0508	0.0611	0.0758	0.0840	0.0607	0.0744	0.0669	0.0153	0.0148	0.0081	0.0020	0.0021	0.0501
	G	-0.1819	-0.3643	0.0024	-0.0706	-0.1604	-0.0866	-0.0440	0.0846	-0.3381	-0.2948	-0.3707	-0.3705	-0.3976	-0.3601	-0.4185	-0.1144	-0.0705	-0.0428	-0.0139	-0.0249	-0.2513
CSL	P	0.0008	0.0023	-0.0001	0.0001	0.0009	0.0003	0.0002	-0.0005	0.0015	0.0017	0.0020	0.0023	0.0032	0.0019	0.0019	0.0002	0.0006	0.0004	0.0002	0.0000	0.0013
	G	0.0099	0.0207	0.0017	0.0059	0.0078	0.0070	0.0053	-0.0026	0.0215	0.0174	0.0222	0.0217	0.0202	0.0221	0.0243	0.0097	0.0052	0.0019	0.0024	0.0002	0.0141
NPC	P	-0.0097	-0.0161	0.0009	-0.0028	-0.0075	-0.0025	0.0001	0.0045	-0.0136	-0.0137	-0.0179	-0.0182	-0.0125	-0.0206	-0.0163	-0.0022	-0.0023	-0.0017	-0.0021	-0.0001	-0.0114
	G	-0.1813	-0.3199	0.0149	-0.0691	-0.1686	-0.1026	-0.0438	0.0753	-0.2614	-0.2562	-0.3540	-0.3377	-0.3793	-0.3475	-0.3765	-0.1060	-0.0435	-0.0714	-0.0444	0.0251	-0.2204
NPP	P	0.0503	0.0994	0.0037	0.0192	0.0406	0.0223	0.0125	-0.0118	0.0746	0.0835	0.1003	0.0979	0.0735	0.0969	0.1228	0.0145	0.0185	0.0050	0.0041	0.0025	0.0693
	G	-0.0695	-0.1426	0.0102	-0.0213	-0.0612	-0.0303	-0.0094	0.0414	-0.1278	-0.1114	-0.1476	-0.1542	-0.1638	-0.1479	-0.1365	-0.0523	-0.0212	-0.0270	-0.0083	-0.0049	-0.0926
NSP	P	-0.0022	-0.0030	0.0001	-0.0035	-0.0008	0.0011	0.0012	0.0004	0.0005	0.0013	-0.0021	-0.0025	-0.0010	-0.0014	-0.0016	-0.0136	0.0009	-0.0037	-0.0028	0.0012	-0.0010
	G	-0.0254	-0.0707	-0.0241	-0.0842	-0.0341	0.0743	0.0692	0.0669	-0.0539	0.0137	-0.0484	-0.0502	-0.0778	-0.0497	-0.0623	-0.1627	0.0221	-0.0454	-0.0405	0.0295	-0.0349
AAC	P	0.0042	0.0005	0.0042	0.0027	0.0093	0.0051	0.0047	0.0023	-0.0010	0.0092	0.0052	0.0042	0.0044	0.0026	0.0036	-0.0015	0.0237	-0.0090	0.0033	0.0032	0.0117
	G	0.0039	0.0003	0.0043	0.0036	0.0090	0.0060	0.0058	0.0021	-0.0013	0.0081	0.0043	0.0038	0.0052	0.0025	0.0031	-0.0027	0.0201	-0.0094	0.0027	0.0033	0.0106
TSS	P	-0.0004	0.0007	-0.0002	0.0002	-0.0004	-0.0004	-0.0004	-0.0002	0.0005	0.0000	0.0004	0.0004	0.0005	0.0004	0.0002	0.0012	-0.0017	0.0045	-0.0002	-0.0002	-0.0008
	G	-0.0134	0.0246	0.0078	0.0111	-0.0029	-0.0316	-0.0355	-0.0240	0.0522	-0.0005	0.0244	0.0165	0.0134	0.0293	0.0282	0.0398	-0.0668	0.1428	-0.0069	-0.0245	-0.0320
PC	P	0.0008	-0.0002	0.0004	0.0007	0.0011	-0.0026	-0.0028	-0.0030	0.0000	0.0007	0.0006	0.0002	0.0006	0.0010	0.0003	0.0019	0.0013	-0.0004	0.0094	0.0006	0.0024
	G	0.0326	-0.0124	0.0110	0.0320	0.0438	-0.1408	-0.1549	-0.1682	0.0010	0.0261	0.0171	0.0118	0.0380	0.0402	0.0190	0.0783	0.0421	-0.0151	0.3143	0.0246	0.0892
TA	P	0.0015	-0.0012	-0.0007	-0.0003	0.0008	-0.0009	-0.0016	0.0007	-0.0020	0.0001	0.0008	-0.0003	0.0002	0.0000	-0.0003	0.0012	-0.0018	0.0005	-0.0009	-0.0134	-0.0017
	G	0.0203	-0.0153	-0.0007	0.0095	0.0139	0.0004	-0.0066	0.0139	-0.0052	0.0037	0.0022	-0.0077	-0.0009	0.0083	-0.0041	0.0208	-0.0190	0.0197	-0.0090	-0.1149	-0.0180
100S	P	-0.0269	-0.0267	-0.0023	-0.0047	-0.0252	-0.0085	-0.0054	0.0064	-0.0108	-0.0392	-0.0295	-0.0326	-0.0227	-0.0303	-0.0309	-0.0039	-0.0270	0.0095	-0.0140	-0.0071	-0.0547
	G	-0.0875	-0.0815	-0.0040	-0.0213	-0.0934	-0.0331	-0.0222	0.0259	-0.0503	-0.1192	-0.0985	-0.1076	-0.1102	-0.1006	-0.1076	-0.0340	-0.0834	0.0355	-0.0450	-0.0248	-0.1586

*significant at 5% LOS ** significant at 1 % LOS

VL= Vine Length (cm) ; NPB= Number of Primary branches ; TLL= Leaf length (cm) ; TLB= Leaf breadth (cm) ; NN= Number of nodes per plant ; DF= Days to first flowering ; DFF = Days to 50% flowering ; DFH=Days to first harvesting ; LHP=Length of harvesting period (days**)** ; PL= Pod length ; PG= Pod girth ; NCP= No. of clusters per plant ; CSL= Cluster stalk length (cm) ; NPC= No. of pods per cluster ; NPP= Number of pods per plant ; SNP= Seed number per pod ; AA=Ascorbic acid content (mg/100g) ; TSS=Total soluble solids ; PC=Protein percent ; TA=Titrable acidity ; SW= Seed weight; PYP= Pod yield per plant per plant at genotypic level. Terminal leaf length showed moderate positive direct effect on pod yield per plant at genotypic level (0.2848 G) and low positive direct effect on pod yield per plant at phenotypic level (0.1028 P). Length of harvesting period (0.1392 G) showed low positive direct effect on pod yield per plant at genotypic level. Pod length recorded moderate positive direct effect on pod yield per plant at genotypic level (0.2920 G) and negligible positive direct effect on pod yield per plant (0.0165 P) at phenotypic level. Pod girth (0.0912 G) exhibited negligible positive direct effect on pod yield per plant at genotypic level. Length of cluster stalk (0.0202 G, 0.0032 P) showed negligible positive direct effect on pod yield per plant at genotypic and phenotypic levels respectively.

Ascorbic acid content recorded negligible positive direct effect on pod yield per plant (0.0201 G, 0.0237 P) at genotypic level and phenotypic levels. TSS exhibited low positive direct effect on pod yield per plant (0.1428 G) at genotypic level and negligible positive direct effect on pod yield per plant (0.0045 P) at phenotypic level. Similar results were obtained by Ravi Naik *et al.* (2014) [4] in dolichos bean, Sapara and Javia (2014) [5] in cowpea, Singh *et al.* (2015) [6] in dolichos bean, Rambabu *et al.* (2016) [3] in yardlong bean, Srinivas *et al.* (2017) [7] in cowpea and Jyothi Reddy *et al.* (2018) in dolichos bean.

Conclusion

The relationship between yield and yield contributing characters in different genotypes of yardlong bean through path analysis revealed that number of primary branches per plant (1.2042 G) and days to 50 % flowering (1.0309 G) exhibited very high positive direct effect on pod yield per plant. Therefore, selection for these characters would give better response.

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