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Path coefficient analysis for yield and its component traits in cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.] for vegetable pod yield and seed yield parameters

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Abstract
An experiment was carried out to study the direct and indirect effects on the pod and seed yield in cluster bean using 15 accessions. The path coefficient analysis which splits total correlated coefficient of different characters into direct and indirect effects on pod and seed yield per plant in such a manner that the sum of direct and indirect effects is equal to total genotypic correlated. The significant difference among the genotypes for all the characters under study suggested that there was ample scope for selection of promising cluster bean genotypes for vegetable yield and seed yield improvement. Pods/plant had positive direct effect on pod yield/plant. It exhibited positive indirect effect through days to 1st flowering, days to 50% flowering, plant height 45 days, plant height 90 days, days to 1st pod picking, ten fresh pod weight, pod length and pod yield/plant. Fruit clusters/plant had direct negative effect on seed yield/plant. It exhibited positive indirect effect through seeds/pod and 100 seed weight. Seeds/pod had direct negative effect on seed yield/plant. It exhibited positive indirect effect through fruit clusters/plant and pods/cluster.

Keywords: cluster bean [*Cyamopsis tetragonoloba* (L.)], pod and seed yield and path analysis

Introduction
Cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.], also known as guar, is arid legume crop that is cultivated mostly in the arid and semi arid areas as it is drought resistant. Guar is well adapted to arid and semi arid regions due to presence of long, deep and well developed lateral roots.

Guar is suitable for the areas with light to medium textured soils, no water logging, rain fall range of 250 – 450 mm with 3-4 spells, ideal temperature range of 25°C to 40°C. Seeds of cluster bean have a large endosperm when compared to other legumes, and contains galactomannan type of gum, which forms a viscous gel and has diversified industrial applications *viz*., paper, food, cosmetics, mining, petroleum, well drilling, pharmaceuticals etc. (Pathak *et al*., 2009) [6]. In order to enhance the productivity, information on the nature and magnitude of genetic diversity present in the genotypes is a pre-requisite. Path coefficient analysis is simply a standardized partial coefficient which splits the correlation coefficient into the measures of direct and indirect effects (Wright, 1921) [12]. In other words, it measures of direct and indirect selection for genetic improvement of yield. Selection for a component tarit with a view to improve yield is called indirect selection, while selection for yield per se is termed as direct selection. A greater yield response is obtain when the characters for which indirect selection is practiced has a high heritability and a high correlation with yield. They was given the minimum combinations of heritability and correlation coefficient values necessary for indirect selection to be more efficient than the direct selection for yield.

Materials and Methods
The experiment will be carried out at the Horticulture Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad. The experiment will be conducted in Randomized block design having 15 (genotypes) in three replications. The allocation of treatments of the individual plots using random number in each replication.

Uniformly grown five plants under each replication were selected and tagged for recording observations for the following characters viz., plant height 45 and 90 days (cm), No. of branches 45 and 90 days, Days to 1st flowering, Days to 50 per cent flowering, Days to 1st

pod picking, Pod length (cm), Pod width (cm), Ten fresh pod weight (g), Number of clusters per plant, Number of pods per cluster, No. of pods per plant, pod yield per plant (g), pod yield per hectare (q), Ten dry pod weight (g), No of seed per pod, Hundred seed weight (g), Seed yield per plant (g), Seed yield/ha (q).

Allahabad is situated at an elevation of 78 meters above sea level at 25.87-degree North latitude and 81.15-degree E longitude. This region has a sub-tropical climate prevailing in the south-east part of U.P. with both the extremes in temperature, i.e. the winter and the summer. In cold winters, the temperature sometimes is as low as 32°F in December – January and very hot summer with temperature reaching up to 115°F in the months of May and June. During winter, frosts and during summer, hot scorching winds are also not uncommon. The average rainfall is around 1013.4 mm, with maximum concentration during July to September months with occasional showers in winter.

Result

The analysis of variance showed that significant difference among the genotypes for all 20 characters studied. Similar findings were reported by Vir *et al*., (2015) [11], kumar *et al*., (2015) [3], Malaghan *et al.*, (2014) [5], Preeti *et al.* (2018) Rai *et al.*, (2012) [7] also recorded highly significant difference among the cluster bean genotypes with respect to all the characters under studied. The path coefficient analysis (presented in table 1 & 2) which splits total correlated coefficient of different characters into direct and indirect effects on fruit yield per plant in such a manner that the sum of direct and indirect effects is equal to total genotypic correlated. The results of the path analysis for different pod yield characters of cluster bean are presented in (Table 1). Pods/plant had positive direct effect (1.0585) on pod yield/plant. It exhibited positive indirect effect through days to 1st flowering (0.4625), days to 50% flowering (0.4672), plant height 45 days (0.8618), plant height 90 days (0.3918), days to 1st pod picking (0.3505), ten fresh pod weight (0.1043), pod length (0.2252) and pod yield/plant (0.9415), while the other characters like negative indirect effect were seen through branches/plant 45 days (-0.3579), branches/plant 90 days (-0.3193) and pod width (-0.1550).

Table 1: Genotypic path coefficient analysis for vegetable pod yield and its component characters

Characters	1	2	3	4	5	6	7	8	9	10	11	12
1	-0.9893	-1.0030	-0.6507	-0.1102	0.3897	0.4523	-0.9495	-0.2966	-0.4235	0.0795	-0.4323	-0.4984
2	-0.4671	-0.4607	-0.3275	-0.0482	0.2109	0.2320	-0.4492	-0.1450	-0.1990	0.0052	-0.2033	-0.2446
3	0.3149	0.3403	0.4787	0.2572	-0.1518	-0.1474	0.1945	0.1871	0.2181	-0.0044	0.3897	0.4215
4	-0.0187	-0.0176	-0.0901	-0.1677	0.0390	0.0293	0.0491	-0.0802	-0.1089	-0.0920	-0.0621	-0.0779
5	-0.1426	-0.1657	-0.1148	-0.0843	0.3619	0.3621	-0.0556	-0.1645	-0.1794	-0.1676	-0.1224	-0.1835
6	0.2276	0.2507	0.1532	0.0869	-0.4980	-0.4977	0.1361	0.1781	0.2233	0.2046	0.1501	0.2354
7	0.1422	0.1445	0.0602	-0.0434	-0.0228	-0.0405	0.1482	-0.0189	0.0030	-0.0444	0.0491	0.0312
8	0.1960	0.2057	0.2554	0.3128	-0.2972	-0.2339	-0.0832	0.6536	0.5746	0.3968	0.0644	0.2719
9	-0.1680	-0.1695	-0.1788	-0.2549	0.1945	0.1760	-0.0079	-0.3449	-0.3924	-0.2264	-0.0835	-0.1560
10	0.0180	0.0025	0.0020	-0.1228	0.1037	0.0920	0.0671	-0.1359	-0.1292	-0.2238	0.0328	-0.0232
11	0.4625	0.4672	0.8618	0.3918	-0.3579	-0.3193	0.3505	0.1043	0.2252	-0.1550	1.0585	0.9415
12	-0.7398	-0.7798	-1.2932	-0.6825	0.7448	0.6946	-0.3093	-0.6110	-0.5839	-0.1522	-1.3062	-1.4686

1. Days to 1st Flowering 2. Days to 50% Flowering 3. Plant height 45days (cm)
4. Plant height 90 Days (cm) 5. Branches/plant 45 days 6. Branches/plant 90 days
7. Days to 1st pod picking 8. 10fresh pod weight (g) 9. Pod length (cm)
10. Pod width (cm) 11. Pods/plant 12. Pod yield/plant (g)

Days to 50% flowering had direct negative effect (-0.4607) on pod yield/plant. It exhibited positive indirect effect through branches/plant 45 days (0.2109), branches/plant 90 days (0.2320) and pod width (0.0052). Plant height 90 days had direct negative effect (-0.1677) on pod yield/plant. It exhibited positive indirect effect through branches/plant 45 days (0.0390), branches/plant 90 days (0.0293) and days to 1st pod picking (0.0491). Branches/plant 90 days had direct negative effect (-0.4977) on pod yield/plant. It exhibited positive indirect effect through days to 1st flowering (0.2276), days to 50% flowering (0.2507), plant height 45 days (0.1532), plant height 90 days (0.0869), days to 1st pod picking (0.1361), ten fresh pod weight (0.1718), pod length (0.2233), pod width (0.2046), pods/plant (0.1501) and pod yield/plant (0.2354). Ten fresh pod weight had positive direct effect (0.6536) on pod yield/plant. It exhibited positive indirect effect through days to 1st flowering (0.1960), days to 50% flowering (0.2057), plant height 45 days (0.2554), plant height 90 days (0.3128), pod length (0.5746), pod width (0.3968), pods/plant (0.0644) and pod yield/plant (0.2719). Pod length had direct negative effect (-0.3924) on pod yield/plant. It exhibited positive indirect effect through branches/plant 45 days (0.1945) and branches/plant 90 days (0.1760). Pod width had direct negative effect (-0.2238) on pod yield/plant. It exhibited positive indirect effect through days to 1st flowering (0.0180), days to 50% flowering (0.0025), plant height 45 days (0.0020), branches/plant 45 days (0.1037), branches/plant 90 days (0.0920), days to 1st pod picking (0.0671) and pods/plant (0.0328). This result is in line with the findings of Kalaiselvan and Irulappan (1985) [2] in winged bean, Kumaran *et al*., (1995) [4], Ramesh and Tewatia (2002) [9] and Shridhar (2005) [10] in peas, Ramaprasad *et al*., (2007) [8] in french bean, Ibrahim *et al*., (2012) [1] in cluster bean for the above characters.

Table 2: Genotypic path coefficient analysis for seed yield and its component characters

Characters	Fruit clusters/ Plant	Pods/cluster	10 dry pod weight (g)	Seeds/pod	100 seed weight (g),
Fruit clusters/ Plant	-0.5156	-0.5410	-0.0785	0.2420	0.3207
Pods/ Cluster	0.4918	0.4687	0.0836	-0.1629	-0.3193
10 Dry Pod Weight (g)	0.1066	0.1248	0.7003	0.3031	-0.2572
Seeds/ Pod	0.4331	0.3208	-0.3994	-0.9228	-0.0528
100 Seed Weight (g)	-0.1625	-0.1780	-0.0959	0.0150	0.2612
Seed Yield/ Plant (g)	0.2902	0.2818	-0.5432	-0.6609	0.0299

The results of the path analysis for different seed yield characters of cluster bean are presented in (Table 2). Fruit clusters/plant had direct negative effect (-0.5156) on seed yield/plant. It exhibited positive indirect effect through seeds/pod (0.2420) and 100 seed weight (0.3207), while the other characters like negative indirect effect were seen through pods/cluster (-0.5410) and 10 dry pod weight (-0.0785). Pods/cluster had positive direct effect (0.4687) on seed yield/plant. It exhibited positive indirect effect fruit clusters/plant (0.4918) and 10 dry pod weight (0.0836), while the other characters like negative indirect effect were seen through seeds/pod (-0.1629) and 100 seed weight (-0.3193). 10 dry pod weight had positive direct effect (0.7003) on seed yield/plant. It exhibited positive indirect effect through fruit clusters/plant (0.1066), pods/cluster (0.1248) and seeds/pod (0.3031), while the other characters like negative indirect effect were seen through100 seed weight (-.2572).

Seeds/pod had direct negative effect (-0.9228) on seed yield/plant. It exhibited positive indirect effect through fruit clusters/plant (0.4331) and pods/cluster (0.3208), while the other characters like negative indirect effect were seen through10 dry pod weight (-0.3994) and 100 seed weight (-0.0528). 100 seed weight had positive direct effect (0.2612) on seed yield/plant. It exhibited positive indirect effect through seeds/pod (0.0150), while the other characters like negative indirect effect were seen through fruit clusters/plant (-0.1625), pods/cluster (-0.1780) and 10 dry pod weight (-0.0959).

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