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Genetic analysis for Yield and Yield Contributing Traits in Vegetable Type genotypes in Pigeon pea (*Cajanus Cajan* (L.)

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ABSTRACT: *Genetic analysis of 24 vegetable type genotypes in Pigeon pea (Cajanus Cajan(L.) was studied by using variability,correlation and path coefficient analysis to find out the variation, association among characters and to measure the direct and indirect contribution of eleven characters on green pod yield per plant. Genotypic and phenotypic coefficient of variation were of high magnitude for plant height,100 green pod weight,100 green seed weight, Shelling percentage (%), TSS (%), days to50% flowering, pod length, pod width as well as for number of primary branches. The estimate of high heritability (bs) accompanied with high-expected genetic advance for 100 green pod weight and days to 50% flowering indicating the presence of additive gene action in the expression of these characters. This suggesting that such traits can be improved by direct selection.The genotypic correlation studies pod length (0.2266), pod width (0.1127), seed per pod (0.0026),100green pod weight (0.0383), 100green seed weight (0.3583), shelling percentage (0.4283), number of flower cluster (0.2260) indicated that green pod yield per plant exhibited stable positive association with traits expect days to 50% flowering (-0.1917), number of primary branches (-0.0479) and TSS (-0.0342). While the phenotypic correlation revealed that, days to 50% flowering (-0.1731), number of primary branches (-0.0358) and TSS (-0.0387) were negatively correlated and the rest of all characters were positively correlatedwith green pod yield per plant. The direct effects of path coefficient analysis revealed that the greenpod yield per plant had positive and significant with days to 50% flowering (0.0588), pod width (0.9276), pod length (0.4526),seed per pod (0.0062), 100 greenpod weight (0.0652), 100green seed weight (0.2128), shelling percentage (0.3972), number of flower cluster (0.3709) and the rest of the effects of few characters were negative for number of primary branches(-0.0246) and TSS (-0.0068). Moreover, it was noticed that, high indirect contribution was contributed through green pod yield per pod with most of the yield contributing traits. Hence, the traitsviz., 100 green pod weight, days to 50% flowering, seeds per pod and 100green seed weight should be given more consideration while deciding about selection criteria for vegetable type genotypes in pigeonpea.*

INTRODUCTION

Pigeonpea (*Cajanuscajan* (L.) is one of the most important food legumes grown in over 82 countries across the globe, it ranks as the world's fifth most important pulse crop. The crop is cultivated in an estimated area of 2.9 million hectares in the world with an average of 684 kg/ha. Among legumes, pigeonpea or red gram occupies an important place in rainfed agriculture. Globally, it is cultivated on 4.67 million hectares, out of which, 3.30 million hectares is confined to India alone. Although the crop is known to be grown in 22 countries, the major producers are only a few. The major pigeon pea producing areas in the world are India, Eastern Africa, Central and South America, the Caribbean and West Indies, India with a total area of 2.6 million hectares and an average yield of 719 kg/ha produces nearly 92% of the world's entire pigeonpea crop, though the average seed yields are relatively low, the crop can yield 16-29qt/ha under favorable management; while an exceptional yield of 7-8 qt/ha under dry land condition has been reported (Gowda*et al.*,2011). The average yields of green pod are relatively vary, as per the crop management under favorable conditions and yield with range of 36-49qt/ha. (Saxena*et al.*, 2010b).About 90% of pigeon pea constituting medium and late maturing genotypes is either inter cropped. It is mainly cultivated for its dry seeds and green vegetables in dry areas of the tropics and subtropics.Pigeon pea is highly proteinaceous crop and the seed can be prepared into various meals and served as substitute for cow pea and green pea.

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Pigeonpea is cultivated in a wide range of cropping systems and so is its usage. It is energy rich but is cultivated largely under energy starvation condition. In some parts of India including Gujarat, Karnataka, Maharashtra, Tamilnadu, Madhya Pradesh and Andra Pradesh the use of immature shelled seeds is very common as fresh vegetable. It can become one of the mostnutritionally rich vegetables of the daily cuisine, especially for the poor in India, Nepal and Myanmar.

India is world's biggest home of vegetarian in habitants and legumes are main source of protein in their diet, pods are consumed fresh, or processed as vegetable either dried seed are used as *dal* or variety of preparation. A vegetable type pigeon pea of perennial nature has been identified and explored from Vaishali district of Bihar (Singh, 2012).

The pigeonpea is well balanced nutritionally and an excellent source of protein whether eaten as a green pea or as dried grain. In addition to protein, pigeonpea provides carbohydrates and 5-fold higher levels of Vitamin A and C. Pigeonpea seeds are known to be rich in proteins (generally varying from 18 to 25% and as high as 32%), carbohydrates and minerals. Likewise, the seeds are rich in sulphur-containing amino acids, methionine and cysteine. Its abundance in protein makes it an ideal supplement to traditional cereal, banana or tuber-based diets of poor farmers that are generally protein deficient.Vegetable pigeonpea a highly nutritive potential crop for all ages.

Vegetable pigeonpea is a good source of protein, vitamins (A,C, B complex), minerals (Ca, Fe, Zn, Cu), carbohydrates and dietary fiber. In comparison to green peas (*Pisumsativum*), the vegetable pigeonpea has five times more beta carotene content, three times more thiamine, riboflvin and niacin content. Besides it has higher shelling percent (72%) than that of green peas (53%). These all factors indicate that pigeonpea is nutritionally rich vegetable and itcan be used in daily cuisine (Saxena *et al.* 2010a).

The other food items that can be prepared from pigeonpea are fresh sprouts, Tempe, ketchup, noodles, snacks and various extruded food products by Sexena *et al*. (2010c). Pigeonpea floor is an excellent component in the snacks industry and been recommended as an ingredient to increase the nutritional value of pasta without affecting its sensory properties.In India, de-hulled split cotyledons of dry pigeonpea seed are cooked to make *dal* or *sambar* foreating with *chapati* or rice; while in southern and eastern Africa and South America, whole dry seedsare used for porridge, and its green seeds are used as fresh, frozen, or canned vegetable. (Gowda *et al.* 2011).

Crop yield is one of the complex characters controlled by several interacting genotypic and environmental factors. There are quite few yield components which are less complex, highly inherited and less influenced by the environmental changes. In the present study, the genetic variation among Pigeon pea genotypes was studied, for improvement of the crop yield based on the available breeding strategies for selection of parental lines.

The objectives of this study were to evaluate the variability, degree of association between green pod yield components and morphological traits and to determine the direct and indirect effects of yield and its component traits on green pod yield in pigeonpea grown for vegetable purpose.

MATERIAL AND METHODS

The field experiment was conducted during the *Kharif* season of 2013-14 the field of Agril. Botany, Department, PGI, Dr. Pujabrao Deshmukh Krishi Vidyapeeth, Akola. The experimental material consisted 24 germplasm lines of pigeon pea along with a two checks GT-100 and ICP-7035 for yield and other agronomic characters, the experiment was laid out in a Randomized Complete Block Design with three replications.On the basis of yield contributing traits, vegetable type pigeon pea germplasm were selected from the 91 different lines, which were collected from different research stations working on vegetable type pigeon pea in India. The twenty fourgenotypes *viz*., PT-04-253, BDN-2004-3, AKTM-10-4, AKTM-10-6, AKTM-11-18, BDN-2, RPS 2007-10, AKTM-11-11, BDN-2004, AKTM-11-17, BDN-2005, PT-04-254, AKTM-10-10, BDN-2001-09, AKTM-11-24, AKTM-11-07, AKTM-11-10, BDN-2010-3, AKTM-11-12, BDN-2001-07, PKV-TARA,ICPL-87, ICP-7035(C) and GT-100 (C).The following data was collected on days to 50 percent (%) flowering, pod length (cm), pod width (cm), plant height (cm), seedper pod,100 green pod weight (g), 100 green seed weight (g), shelling percentage (%), number of flower cluster,number of primary branches, TSS percentage (%) and Green pod yield (g/per plant).Genetic and phenotypic coefficients of variance was estimated as suggested by Burton (1951) and heritability as suggested by Johnson *et al.* 1955. Genotypic and phenotypic correlation was estimated as suggested bySingh and Chaoudhari (1977) and Path coefficient analysis was estimated as suggested byDewey and Lu (1959).

RESULTS AND DISCUSSION

Variability Studies

Variability studies reveled that genotypic and phenotypic coefficient of variation were of high magnitude for plant height, 100 green pod weight,100 green seed weight, Shelling percentage (%), TSS (%), days to 50% flowering, pod length, pod width as well as for number of primary branches. The analysis revealed significant differences among all genotypes for all the characters presence of considerable amount genetic variability in the materials under study. While, looking to the estimates of GCV and PCV (Table 1), it was observed that the GCV and PCV were high magnitude for TSS (%) followed by 100 green seed weight, pod length, 100 green pod weight, number of primary branches and number of flower cluster. The estimate of high heritability (bs) accompanied with high-expected genetic advance for 100 green pod weight and days to 50% flowering indicating the presence of additive gene action in the expression of these characters. This suggesting that such traits can be improved by direct selection.

The magnitutudal difference between PCV and GCV estimate was maximum for plant height, number of primary branches, number of flower cluster and 100 green seed weight, suggesting influence of environment on these traits. However, the difference between PCV and GCV estimate was minimum for 100 green pod weight, pod length, pod width, TSS(%), Day to 50% flowering, seed per pod and shelling percentage (%) suggesting little influence of environment on these traits and one of may rely on phenotypic value for direct selection.

Ponnuswamy *et al*. (1983) reported that significant differences were observed among the eight vegetable soybean varieties for all the characters studied. The highest values ofheritability and genetic advance were observed for number of green pods per plant and green podyield per plant. The magnitude of GCV for all the traits, suggesting the role of environmental variance. The characters *viz*., pod width, plant height and shelling percentage (%) exhibited very low GCV and PCV estimate suggesting the narrow range of variation for traits. These results are in agreement with the earlier findings of Chetukuri*et al.* (2013) in pigeonpea.

The estimation of heritability (bs) were of high magnitude for 100 green pod weight and days to 50% flowering indicating the major role of genotypic and ultimately less environmental influence.

Sureja *et al.* (2000) reported genetic variability for pod yield in pea and its component characters. High heritability in association with high genetic advance observed for plant height, pod yield per plant, number of pods per plant, seed yield per plant, number of primary branches and 100 seed weight. Green pod yield, the character of prime importance had the moderate estimate of heritability but high genetic advance when compared with other characters. The present results are in accordance with the results obtained by Nausherwan *et al*. (2008) with respect to genetic advance.

Genotypic and Phenotypic Correlation Analysis

The genotypic and phenotypic correlation for the association among the characters studied for the 24 genotypes were shown in Table 2. The genotypic correlation of green pod yield per plant was found to be positively correlated with pod length (0.2266), pod width (0.1127), seed per pod (0.0026), 100 green pod weight (0.0383), 100green seed weight (0.3583),

Table 1
Means, Ranges, Standard deviation and Coefficient of variability (C.V%) for characters evaluated in Pigeonpea

Sr.No.	*Character*	*Mean*	*Range*	*GCV*	*PCV*	*C.V. (%)*	*Heritability (h^2) (BS)*	*Genetic Advance (GA)*
1	Days to 50% flowering	125.34	110-140	5.35	5.85	2.37	0.83	12.63
2	Pod length (cm)	5.53	4.6-7.0	10.98	11.45	3.26	0.91	1.20
3	Pod width (mm)	12.85	11.4-14.3	5.33	5.47	1.22	0.95	1.37
4	Plant height (cm)	187.82	120-220	5.63	8.55	6.43	0.43	14.36
5	Seed per pod	3.66	3.2-4.2	7.09	7.51	2.49	0.88	0.50
6	100 green pod weight (g)	131.23	105.3-161.2	9.85	9.93	1.31	0.98	26.11
7	100 green seed weight (g)	19.39	8.3-25.3	11.36	13.26	6.83	0.73	3.89
8	Shelling percentage (%)	65.82	53.8-76.4	6.59	7.07	2.55	0.86	8.34
9	No. of flower cluster	4.57	3.5-5.6	8.51	11.54	7.87	0.54	0.59
10	No. of primary branches	3.46	2.5-4.5	8.82	11.92	8.01	0.54	0.46
11	TSS%	12.95	8.5-18.5	18.05	18.20	2.33	0.98	4.77

Table 2
Genotypic and Phenotypic Correlation coefficient of various yield and yield contributing characters in vegetable Pigeon pea

		Days to 50% flowering	*Pod length (cm)*	*Pod width (cm)*	*Plant height (cm)*	*Seedper pod*	*100 pod weight (g)*	*100 seed weight (g)*	*Shelling percent (%)*	*No. flower cluster*	*No. primary branches*	*TSS%*	*Green pod yield per plant*
Days to 50% flowering	rg	1	-0.3611	-0.1427	-0.0174	-0.1930	-0.0119	0.1699	0.0327	-0.3613	-0.2632	-0.2109	-0.1917
	rp	1	-0.3339	-0.1186	0.0706	-0.1474	-0.0140	0.1533	-0.0146	-0.2926	-0.1159	-0.2129	-0.1731*
Pod length (cm)	rg		1	0.8803	0.0158	0.6396	0.5195	0.0964	0.1656	0.0875	-0.0900	0.0372	0.2266
	rp			0.8273	-0.0002	0.5665	0.4936	0.0621	0.1560	0.0386	-0.0550	0.0357	0.2184*
Pod width (cm)	rg			1	0.1417	0.6785	0.5568	0.1517	0.0961	0.2503	-0.3876	-0.1182	0.1127
	rp				0.0947	0.6146	0.5411	0.0984	0.0558	0.1646	-0.2745	-0.1130	0.1098*
Plant height (cm)	rg				1	0.1260	0.1102	0.2009	0.2054	-0.0767	-0.4253	-0.0786	-0.0271
	rp					0.1218	0.0845	0.1453	0.0861	-0.0696	-0.1827	-0.0321	-0.0208
Seed per pod	rg					1	0.3474	-0.1646	0.0063	0.3887	-0.3522	-0.3615	0.0026
	rp						0.3352	-0.1371	0.0076	0.2158	-0.2264	-0.3401	0.0034**
100 pod weight (g)	rg						1	0.4661	-0.0385	0.1023	-0.3326	0.0246	0.0383
	rp							0.3928	-0.0430	0.0751	-0.2264	0.0277	0.0375**
100 seed weight (g)	rg							1	-0.0018	-0.4628	0.2281	0.2928	0.3583
	rp								-0.0279	-0.2235	0.1609	0.2322	0.3105**
Shelling percent (%)	rg								1	0.0468	-0.1153	-0.2533	0.4283
	rp									0.0508	-0.1074	-0.2224	0.4006*
No. flower cluster	rg									1	-0.1445	-0.2444	0.2260
	rp										-0.1860	-0.1817	0.1621
No. primary branches	rg										1	0.4053	-0.0479
	rp											0.2830	-0.0358*
TSS%	rg											1	-0.0342
	rp												-0.0387*

shelling percentage (0.4283), number of flower cluster (0.2260) and the days to 50% flowering (-0.1917), number of primary branches (-0.0479) and TSS (-0.0342) were negatively correlated withgreen pod yield. The phenotypic correlation of green pod yield per plant was found to be positively correlated with pod length (0.2184),pod width (0.1098), seed per pod (0.0034), 100 greenpod weight (0.0375), 100 greenseed weight (0.3105), shelling percentage (0.4006), number of flower cluster (0.1621) and days to 50% flowering (-0.1731), number of primary branches (-0.0358) and TSS (-0.0387) werenegatively correlated.

The genotypic correlation of days to 50% flowering was positively correlated with 100 greenseed weight and shelling percentage (%), but negatively correlated with pod length, pod width, plant height, seed per pod, 100 green pod weight, number of flower cluster, number of primary branches. The genetic correlation of pod length was positively correlated with pod width, plant height, seed per pod, 100green pod weight, 100 greenseed weight, shelling percentage (%), number of flower cluster and TSS, while number of primary branches was negatively correlated.The genotypic correlation of pod width was positively correlated with all traits except number primary branches and TSS.The genotypic and phenotypic correlation of pod width was negatively correlated with number of primary branches and TSS, while plant height, seed per pod, 100 greenpod weight, 100 greenseed weight, shelling percentage (%), and number of flower clusterwere positively correlated.The genetic and phenotypic correlation of seed per pod were positively correlated with 100 green pod weight, shelling percentage (%) and number of flower cluster, while negatively correlated with 100 green seed weight, number of primary branches and TSS.The genotypic and phenotypic correlation of 100 green pod weightwas positively correlated with 100 green seed weight, number of flower cluster and TSS (%), while negatively correlated with shelling percentage (%) and number of primary branches.

Number of pods per plant had significant positive correlations with pod length,number of branches per plant at phenotypic level. Whereas, at genotypic level this traitshowed significant positive correlation with number of branches per plant, pod length and TSS (%). Also significantly negative correlated with days to maturity at both phenotypicand genotypic level. In vegetable type Soybean; Rajput *et al*. (1986), Mishra *et al.* (1988), Amaranath (1986), Kalaimagal (1991) and Nirmala Kumari (1986) have reported positive correlation of number of pods per plant with maximum number of yield contributing characters.

In vegetable soybean, pod width exhibited positive significant correlation with 100 seed weight, TSS (%) at both phenotypic and genotypic level including number ofbranches per plant at genotypic levels. These results are in accordance with the report of Ziqiang Wang *et al*. (2001), where 100 green seed weight exhibited positive significant correlationwith pod width. These results are in conformity with the reports of Ziqiang Wang *et al.* (2001) where100 green seed weight exhibited significantly positive correlation with pod lengthand pod width.Also, reported that the increase or decreases in the pod length results in the increase or decreases in the 100 green seed weight which in turn influenced the green pod yield of the plant.

Path Coefficient of Analysis

The results of path coefficients were partitioned into direct and indirect effects through various yield contributing characters as given in Table 3. The direct effects of days to 50% flowering (0.0588), pod width (0.9276), pod length (0.4526), seed per pod (0.0062), 100 green pod weight (0.0652), 100 green seed weight (0.2128), shelling percentage (0.3972), number of flower cluster (0.3709)were positive and the effect of few characters *viz*., number of primary branches (-0.0246) and TSS (-0.0068) were negative on green pod yield per plant. The highest direct effect was exhibited by 100 green seed weight (0.2128) and it was followed by 100 green pod weight (0.0652). The highest direct effect was exhibited by seed per pod and followed by 100 green seed weight. Figure 1 showed the Path Diagram of yield and yield contributing characteristics in vegetable type Pigeonpea.

Days to 50 per cent flowering, pod width, plant height, number of flower cluster and number of primary branches showed negative indirect effect on green pod yield per plant which indicating the effect of these characters. The character *viz*., seed per pod, pod length, 100 green seed weight, 100 green pod weight and green pod shelling percentage (%) had positive direct effect on green pod yield per plant while, some other traits such as days to 50 per cent flowering, seed per pod and 100 green pod weight. Similar results were obtained by Rajput *et al*. (1986), Mishra *et al.* (1988) and Nausherwan *et al*. (2008).

On the basis of path coefficient studies, Teerawat (2012) suggested that the number ofpods per plant, green pod weight and plant height were important

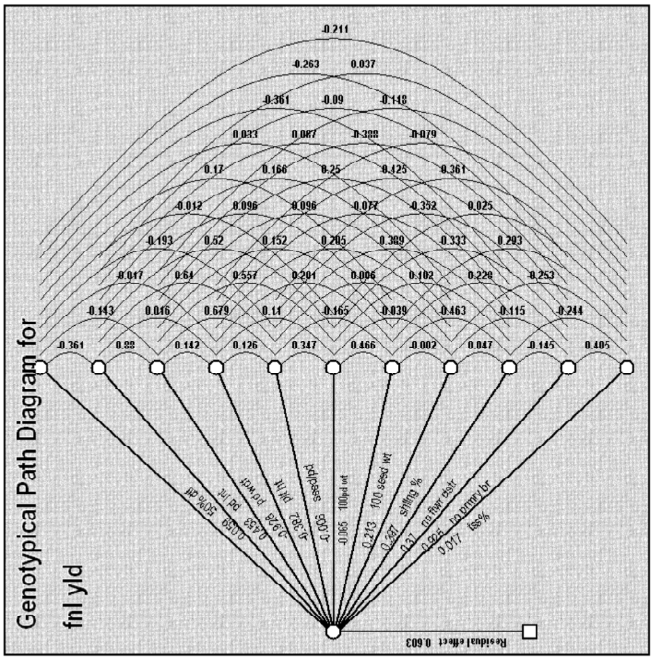

Figure 1: Path Diagram of yield and yield contributing characteristics in vegetable type pigeonpea

characters that should be taken into account as selection criteria in improving marketable pod yield of the vegetable soybean.As per Vijayalakshmi*et al.* (2013), it was noticed that most of the yield components showed the indirect contribution towards green pod yield. Also, number of seed per pod and number seed per plant should be given more consideration while deciding about selection criteria of vegetable type genotypes in soybean.

Thus it is concluded that, estimate of high heritability (bs) accompanied with high-expected genetic advance for 100 green pod weight and days to 50% flowering indicating the presence of additive gene action in the expression of these characters. This suggesting that such traits can be improved by direct selection.The genotypic correlation of green pod yield per plant was found to be positively correlated with pod length, pod width, seed per pod,100 green pod weight, 100 green seed weight, shelling percentage, number of flower cluster. The green pod yield per plantshowed the direct positive effects of characters like, days to 50% flowering, pod width, pod length, seed per pod, 100 green pod weight, 100 green seed weight, shelling percentage, number of flower cluster. Therefor emphasis should be given to 100 green pod weight, seed per pod, 100 green seed weight, shelling percentage and number of flower cluster while selecting genotypes for high green pod yield per plant in vegetable Pigeon pea.

Table 3
Path Coefficient Direct (diagonal) and indirect effect (non-diagonal) of various characters on green pod yield per plant in vegetable Pigeon pea

	Days to 50% flowering	*Pod length (cm)*	*Pod width (cm)*	*Plant height (cm)*	*Seed per pod*	*100 pod weight (g)*	*100 seed weight (g)*	*Shelling percent (%)*	*No. flower cluster*	*No. primary branches*	*TSS%*	*Green pod yield per plant*
Days to 50% flowering	0.0588	-0.0212	-0.0084	-0.0010	-0.0113	-0.0007	0.0100	0.0019	-0.0212	-0.0155	-0.0124	0.1917
Pod length (cm)	-0.1634	0.4526	0.3984	0.0071	0.2895	0.2351	0.0436	0.0750	0.0396	-0.0407	0.0169	0.2266
Pod width (cm)	0.1324	-0.8166	0.9276	-0.1314	-0.6294	-0.5164	-0.1407	-0.0892	-0.2322	0.3595	0.1096	0.1127
Plant height (cm)	0.0066	-0.0060	-0.0541	0.3817	-0.0481	-0.0421	-0.0767	-0.0784	0.0293	0.1623	0.0300	0.0271
Seedper pod	0.0012	-0.0040	-0.0042	-0.0008	0.0062	-0.0021	0.0010	0.0015	-0.0024	0.0022	0.0022	0.0026
100 green pod weight (g)	0.0008	-0.0339	-0.0363	-0.0072	-0.0227	0.0652	-0.0304	0.0025	-0.0067	0.0217	-0.0016	0.0383
100 green seed weight (g)	0.0361	0.0205	0.0323	0.0427	-0.0350	0.0992	0.2128	-0.0004	-0.0985	0.0485	0.0623	0.3583
Shelling percent (%)	0.0130	0.0658	0.0382	0.0816	0.0025	-0.0153	-0.0007	0.3972	0.0186	-0.0458	-0.1006	0.4283
No. flower cluster	-0.1337	0.0324	0.0926	-0.0284	0.1438	0.0379	-0.1712	0.0173	0.3709	-0.0535	-0.0904	0.1226
No. primary branches	0.2434	0.0832	0.3584	0.3932	0.3257	0.3076	-0.2109	0.1066	0.1336	-0.0246	-0.3748	-0.0479
TSS%	-0.0035	0.0006	-0.0020	-0.0013	-0.0061	0.0004	0.0049	-0.0043	-0.0041	0.0068	-0.0068	-0.1342

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