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Studies on Genetic Characteristics of Pigeon Pea Germplasm at Otobi, Benue State of Nigeria

T. Vange and O. Egbe Moses

Department of Plant Breeding and Seed Science, University of Agriculture, Makurdi, Nigeria

Abstract: A three-year study was conducted during the growing season of 2002, 2003 and 2004 at the National Root Crops Research Institute Sub-station, Otobi (07° 10^1N, 08° 39^1E, 105.1m elevation) located in Southern Guinea Savanna agro-ecological zone of Nigeria. The study was conducted to evaluate 29 new pigeon pea genotypes and a local variety for genetic variability, character association and path coefficients among the yield and yield component traits. The experiment was laid out in a Randomized Complete Block Design with three replications. The results indicated that the genotypes showed significant variability for all the traits studied. The phenotypic coefficient of variability and genotypic coefficient of variability were relatively high for number of pods per plant, dry pod weight, dry grain yield and number of primary branches. Phenotypic coefficient of variability and genotypic coefficient of variability were generally moderate for days to 50% flowering, days to maturity and plant height. Heritability (broad sense) was generally high for all the traits with exception of number of seeds per pod (0.58). Relatively high expected genetic advance was obtained for number of branches per plant (58.26%), number of pods per plants (161.84%), dry pod weight (68.48%) and dry grain yield (82.65%). High heritability and expected genetic advance in these traits indicated the presence of additive gene effects. Dry grain yield (tG^{ha}) showed significant positive association with dry pod weight (0.87) and number of primary branches (r = 0.14). The results also revealed the presence of significant negative relationship between dry grain yield and days to 50% flowering (r =-0.14) and days to maturity (r =-0.25). The path coefficient revealed that dry pod weight gave the highest direct effect on dry grain yield (0.84171), followed by pod length (0.05440) and number of pods per plant (0.04605). In this study dry pod weight, pod lengthand number of pods have been identified as selection criteria for obtaining good parental lines in a pigeon pea breeding program.

Key words: Pigeon pea % Genetic variability % Correlation % Path coefficient analysis % Grain yield

INTRODUCTION

Pigeon pea (*Cajanus cajan* (L.) Millsp) is a leguminous crop grown in about 50 countries in the tropics and subtropics. The crop is said to have originated in both Africa and Asia according to FAO [1]. India is the major (90%) world producer of pigeon pea while in Africa Kenya is the largest producer followed by Uganda [2, 3].

According to FAOSTAT [4], Pigeon pea as a field crop was grown on 4.36 ha, with a production of 3.24 million tones and an average productivity of 0.74 tG^{ha}. In Nigeria, farmers incorporate Pigeon pea production into their indigenous cropping systems as field crops, backyard or as field border crops [5, 6]. It is also intercropped with other crops such as maize and yam [7]. Egbe and Adeyemo [8] reported that Pigeon pea can be intercropped with maize without negative effects on the yield and yield components of maize.

Pigeon pea is highly proteineous and the seeds can be prepared into various meals and served as substitute for cowpea. It also provides fuel wood and fodder for the small scale farmers in subsistence agriculture in Nigeria [9].

Pigeon pea research in terms of crop improvement is still at a low level in Nigeria compared to other grain legumes such as cowpea; farmers still cultivate traditional varieties. Determination of genetic diversity of any given crop species is necessary for improvement of the crop because it generates baseline data to guide selection of parental lines and design of breeding scheme. Akande [10] evaluated germplasm from the South-west Nigeriaand recommended mutation breeding, introduction and recombination due to low level of genetic diversity among

Correspoding Author: T. Vange, Department of Plant Breeding and Seed Science, University of Agriculture, Makurdi Nigeria

the germplasm. In the present study, the genetic variation among Pigeon pea collections from ICRISAT with a local variety was studied with the objective of recommending a breeding programme for improvement of the crop.

MATERIALS AND METHODS

In 2002, 2003 and 2004 growing seasons, field experiments were conducted out at the National Root Crops Research Institute Sub-station, Otobi (07° 10 N, 08° 39 E, 105.1m elevation) located in Southern Guinea Savanna agro-ecological zone of Nigeria, to evaluate 29 new pigeon pea genotypes recently obtained from ICRISAT along with a local check for yield and other agronomic characteristics. The genotypes are: ICP 6971, ICP 88039, ICP6930, ICP 8997, ICP 7338, ICP 7400, ICP 440, ICP 1, ICP 7992, ICP 7343, ICP 6443, ICP 6912, ICP 00053, ICP 7188, ICP 11916, ICP 6915, ICP 7613, ICP 7193, ICP 7186, ICP 8257, ICP 11953, ICP 11951, ICP 12746, ICP 7991, ICP 6907, ICP 13030, ICP 7315, ICP 8006, ICP 6967.

Total rainfall at the site between the months of June and November of each year was 1712.00, 1665.60 and 1675.40mm in 2002, 2003 and 2004, respectively. The soil at the experimental site was classified as Typic Paleustalf.

The experiment was laid out in a Randomized Complete Block Design with three replications. The gross plot size was $8m^2$ while the net plot measured $2m^2$. Each gross plot consisted of 4 rows spaced 50cm apart and 4m long. The approximate plant population density for each pigeon genotype was 66,666 per ha. All plots received a basal application of 200 kg of NPK 15:15:15 (30 kg N, 12.90 kg P and 24.90 kg K) per ha by broadcasting. All plots were hand weeded as necessary during the cropping period. The following data were collected: days to 50% flowering, days to physical maturity, plant height at harvest (m), number of effective primary branches, number of pods per plant, dry pod weight and dry grain yield (tG^{ha}). All data collected were analyzed using GENSTAT [11], following Standard Analysis of Variance procedures [12]. Whenever difference between treatment means were significant, means were separated by F-LSD at P = 0.05 [13].

Phenotypic coefficient of variation (PCV), broad sense heritabilityand genotypic coefficient of variation (GCV), were computed following the procedures of Burton and De Vane [14], Expected genetic advance from selection was established using the formular by Allard [15], at 5% selection intensity. Phenotypic linear correlation coefficient was calculated for all possible comparisons using the formula suggested by Al-Jibouri *et al.* [16]. The correlation coefficients were partitioned into direct and indirect effects using the path coefficient analysis according to Dewey and Lu [17] and Wright [18].

RESULTS

The average performance of the 30 pigeon pea genotypes are shown in Table 1. The genotypes varied significantly for all the characters evaluated. Days to 50% flowering and days to maturity varied between 70-199 and 134-260 days, respectively. Also, pod length varied between 3.8 and 8.4 cm, while plant height varied between 1.35 and 4.66 m. The greatest variation was observed in number of pods per plant. The minimum pods per plant were 42 with the maximum value of 668 pods per plant.

The genetic, phenotypic and environmental variances are shown Table 2. Generally the phenotypic variance was higher than genotypic variance.

The environmental variance was, however, low. The phenotypic coefficient of variability and genotypic coefficient of variability were relatively high for number of pods per plant, dry pod weight, dry grain yield and number of primary branches. However, the phenotypic coefficient of variability and genotypic coefficient of variability were generally moderate for days to 50% flowering, days to maturity and plant height. Heritability (broad sense) was generally high for all the traits with the exception of number of seeds per pod.

Number of branches per plant, number of pods per plant, dry pod weight and dry grain yield showed relatively high genetic advance and high heritability estimates. Heritability and genetic advance expressed as percentage of mean are shown in Table 2.

The phenotypic correlations between all the pairs of characters studied are presented in Table 3. The correlation coefficients for some of the characters revealed the presence of strong positive association between dry grain yield (tG^{ha}); Dry grain yield (tG^{ha}) showed significant positive association with dry pod weight and number of primary branches (Table 3).

Also, dry grain yield had positive correlation with number of pods per plant and plant height. The results also revealed the presence of significant negative relationship between dry grain yield and days to 50% flowering and days to maturity.

Table 1: Means, Ranges, standard deviationand Coefficient of Variability (C.V %) for characters evaluated in pigeon pea.

Character	Mean	Standard error (±)	Minimum	Maximum	Standarddeviation	C.V (%)
Days to 50% flowering	135.8	1.200	70.00	199.0	20.00	14.90
Days to maturity	196.5	1.600	134.0	260.0	26.00	13.20
Plant height (m)	3.390	0.030	1.350	4.660	0.49	14.53
Pod length (cm)	5.370	0.039	3.800	8.400	0.64	11.99
Primary branches (no.)	17.68	0.220	9.500	29.00	3.69	20.85
Seeds per pod (no.)	4.130	0.030	2.300	6.000	0.44	10.67
Pods per plant (no.)	195.5	5.000	42.00	668.0	90.00	46.00
Dry pod weight (tG^{ha})	2.890	0.060	0.680	5.730	0.90	31.25
Dry grain yield (t-^{ha})	1.370	0.030	0.140	3.530	0.49	36.15

Seeds per pod, dry pod weight (tG^{ha}) and dry grain yield (tG^{ha}) also varied significantly among the genotypes (Table 1).

Table 2: Genetic parameters for pigeon pea at Otobi, Nigeria

Traits	Means	Genotype variance	Phenotypic variance	Environmental variance	Broad Sense Heritability (h^2)	Genotypic Coefficient of Variability	Phenotypic coefficient of variation	Genetic Advance as % of mean
Days to 50% flowering	135.89	693.07	697.58	4.51	0.99	19.37	19.44	39.78
Days to maturity	195.82	1972.49	1982.13	9.65	1.00	22.68	22.74	46.61
Plant Height (m)	3.39	0.33	0.39	0.06	0.85	16.99	18.42	32.27
Pod length (cm)	5.37	0.66	0.81	0.15	0.81	15.11	16.78	28.03
Primary branches (no.)	17.75	29.85	35.35	5.50	0.84	30.78	33.50	58.26
Seeds per pod (no.)	4.13	0.14	0.25	0.10	0.58	9.14	12.01	14.32
Pods per plant (no.)	195.02	23691.25	23911.43	220.18	0.99	78.93	79.29	161.84
Dry pod weight (tG^{ha})	2.89	1.04	1.18	0.14	0.88	35.35	37.58	68.48
Dry Grain yield (tG^{ha})	1.37	0.35	0.40	0.05	0.88	42.87	45.81	82.65

Table 3: Phenotypic correlation coefficient of yield and yield component of pigeon pea.

Character	Plant height (m)	Days to 50% flowering	Days to maturity	Dry pod weight (tG^{ha})	Pod length (cm)	Primary branches (no.)	Seeds per pod (no.)	Pods per plant (no.)
Dry grain yield (t-^{ha})	0.034	-0.138*	-0.245**	0.873**	0.129*	-0.077	0.052	0.239**
Plant height (m)	-	0.363**	0.314**	0.078	-0.143	0.055	-0.023	0.024
Days to 50% flowering		-	0.754**	-0.094	-0.089	0.141	-0.073	-0.081
Days to maturity			-	-0.175**	-0.180**	0.207**	-0.07	-0.045
Dry pod weight (tG^{ha})				-	0.077	0.011	0.014	0.237**
Pod length (cm)					-	-0.070	-0.097	-0.174**
Primary branches (no.)						-	0.018	-0.100
Seeds per pod (no.)							-	-0.069

*, ** significant at 5 and 1 % level of probability respectively.

The path coefficient analysis of dry grain yield and its components are presented in Figure 1. The path coefficient revealed that dry pod weight gave the highest direct effect on dry grain yield of 0.84171, followed by pod length (0.05440) and number of pods per plant (0.04605).

Dry grain yield had significant and positive correlation with dry pod weight (0.87). The path analysis indicated that the direct effect of dry pod weight on dry grain yield was high and positive (0.84171). Despite the high correlation and direct effect on dry grain yield, the indirect effect of dry pod weight via pod length (0.004227), via days to maturity (0.019223)and number of pods per plant (0.010928) were low.

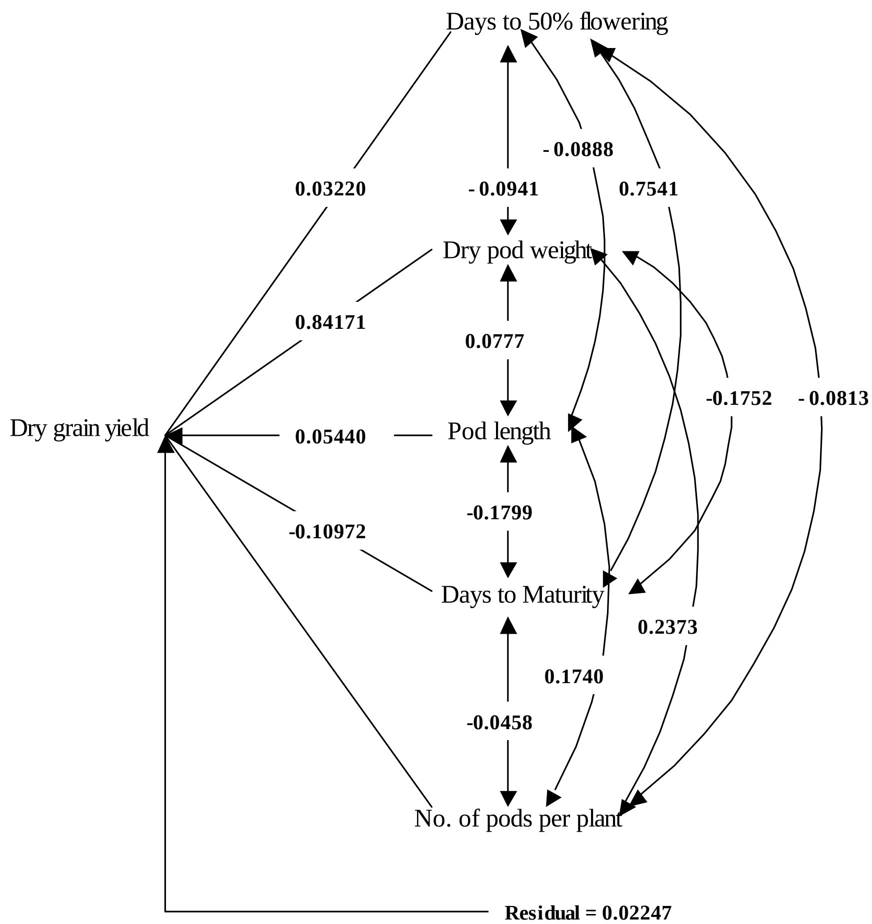

Fig. 1: Path coefficient diagram to dry grain yield of some agronomic traits of pigeon pea

DISCUSSION

The variation observed from the traits studied showed adequate variability in the germplasm. The greatest variation was observed in number of pods per plant. The minimum pods per plant were 42 with the maximum value of 668 pods per plant. Seeds per pod, dry pod weight (tG^{ha}) and dry grain yield (tG^{ha}) also varied significantly among the genotypes. The observed variation will enhance the genetic improvement of the crop for any of these traits evaluated. Akande [10] observed limited variations in traits of pigeon pea germplasm studied from South-West Nigeria.

Generally the phenotypic variance was higher than genotypic variance. The environmental variance was, however, low. This indicates that environmental influences were low compared to genetic factors in the variability observed indicating that the traits have broad genetic base hence improvement can be achieved through selection. The phenotypic coefficient of variability and genotypic coefficient of variability were relatively high for number of pods per plant, dry pod weight, dry grain yield and number of primary branches. However, the phenotypic coefficient of variability and genotypic coefficient of variability were generally moderate for days to 50% flowering, days to maturity and plant height. Heritability (broad sense) was generally high for all the traits with the exception of number of seeds per pod. Number of branches per plant, number of pods per plants, dry pod weight and dry grain yield showed relatively high genetic advance and high heritability estimates. High heritability coupled with high genetic advance indicates the predominance of additive gene effects [19, 20].

The correlation coefficients for some of the characters revealed the presence of strong positive association between dry grain yield (tG^{ha}); Dry grain yield (tG^{ha}) showed significant positive association with dry pod weight and number of primary branches. Also, dry grain yield had positive correlation with number of pods per plant and plant height. Padi [21] reported significant positive correlation between number of pods per plant and yield. The highest and positive direct influence of pods/plant on yield indicated that it is an important yield component. Veeraswamy *et al*. [22] also reported that pods/plant was an important yield component in pigeon pea.

Significant and positive phenotypic association between grain yield and other yield variables are quite desirable in plant breeding, because it facilitates the selection process. The results also revealed the presence of significant negative relationship between dry grain yield and days to 50% flowering and days to maturity. Kaveris *et a.l* [23] reported significant negative correlation of days to 50% with yield in greengram. Days to maturity had significant negative correlation with pod length, dry pod weight and significant positive correlation with number of branches.

The path coefficient revealed that dry pod weight gave the highest direct effect on dry grain yield of 0.84171, followed by pod length (0.05440) and number of pods per plant (0.04605). Dry grain yield had significant and positive correlation with dry pod weight (0.87). The path analysis indicated that the direct effect of dry pod weight on dry grain yield was high and positive (0.84171). Despite the highest correlation and direct effect on dry grain yield, the indirect effect of dry pod weight via pod length (0.004227), via days to maturity (0.019223) and number of pods per plant (0.010928) were low. Apparently, days to 50% flowering modified and lowered the large direct effect of dry pod weight on grain yield via its low and negative indirect effect (-0.00303). According to Izge *et al.* [13], higher indirect values could most likely be neutralized in most cases by negative indirect effects via other characters and this can lead to their low and non-significant genotypic correlations with total yield. In this regards, selection for such characters may not enhance yield improvement and are not to be encouraged.

The direct effects of pod length on dry grain yield has been scaled down by the indirect effect via days to 50% flowering (-0.00286) and number of pods per plant (-0.00801). Despite the highest positive and significant correlation between dry grain yield and dry pod weight, the indirect effect of dry pod weight has been lowered via pod length (0.065401). Also the indirect effect of pod length via days to maturity is low (0.019739).

Number of pods per plant correlated significantly and positively with dry grain yield (0.238403). Number of pods per plant had positive direct effect on dry grain yield. A negative indirect effect was observed via days to 50% flowering (-0.00262) and pod length (-0.00979). The indirect effect via days to maturity was low. However, the indirect effect via dry pod weight was high.

Days to 50% flowering and days to maturity expectedly have similar negative significant correlation with dry grain weight. The direct effect of days to 50% flowering on grain yield was low. A negative indirect effect was registered via dry pod weight (-0.0792), pod length (-0.00483), days to maturity (-0.08274) and number of pods per plant (-0.00374). The direct effect of days to maturity on dry grain yield was negative and low. These was further scaled down by its indirect effects via dry pod weight (-0.14747), pod length (-0.00979) and number of pods per plant (-0.00211).

In this study dry pod weight, pod lengthand number of pods have been identified as selection criteria for obtaining good parental lines in a pigeon pea breeding program.

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