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Genotype x Environment Interaction and Agronomic Performances Analysis in Exotic Pigeon Pea (*Cajanus cajan* L. Millsp) Cultivars in Benin

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Abstract: In Benin, pigeon pea is largely consumed by rural and urban people. Despite its multiple uses, its cultivation is neglected due to the lack of improved varieties. For enhancing pigeon pea production in Benin, some exotic cultivars were introduced in the country. The aim of the present study is to evaluate the agronomic performances and genotype x environment interaction (GEI) of these cultivars. Two trials were conducted in two different environments during the rainy season of 2019-2020. The plant material was composed of 14 cultivars and planted in a randomized complete block design with two replications. Data were recorded on eleven agro-morphological traits and analyzed by using descriptive statistics as well analysis of variance (ANOVA) and analysis of additive main effects and multiplicative interaction (AMMI). For the stability analysis of agronomic traits, Wricke's ecovalence, Shukla's variance and genotypic superiority indexes were calculated. The results revealed that the collection was characterized by short maturity cycle cultivars with flowering date around 90 days. They were very productive genotypes. Grain yield varied from 78.5 to 1476.3 kg/ha. ANOVA based on combined data and AMMI analysis revealed highly significant effect of GEI for all 11 traits. However, some traits presented high value for heritability ($H^2 > 0.5$). Based on three stability indexes, the cultivars ICP7184, ICP6907, MN5 and ICP84023 are the most stable cultivars for grain yield and flowering date. These cultivars could be proposed to growers for cultivation and also used as parental lines in pigeon pea breeding programs.

Keywords: Benin, Pigeon Pea, Genotype x Environment Interaction, AMMI, Wricke's Ecovalence

1. Introduction

Pigeon pea (*Cajanus cajan* (L.) Millsp) is a food legume mainly grown in semi-arid tropical and subtropical regions around the world [1]. India is the largest producer of pigeon pea with a 67.3% contribution to global production followed by Myanmar. In addition to being the largest producer of pigeon pea in the world, India is the center of domestication of the species [2]. The species is cultivated for its seeds that are an important source of protein, minerals and vitamins for nearly 20% of the world's population [3]. In addition to the crucial role, it plays in nutritional and food security, pigeon pea improves soil fertility by its ability to fix atmospheric nitrogen in symbiosis with soil bacteria and brings organic value to the soil through its dead leaves [4].

However, pigeon pea production in Africa accounts for 14% of world production. It is considered as an orphan culture in many countries in West Africa [5]. In Benin, pigeon pea is neglected and underutilized [5, 6]. Its culture faces many problems that hinder its development. According to Zavinon, F. et al [5], the lack of improved cultivars with high yield potential is the major constraint of the pigeon pea production in Benin. In addition, biotic and abiotic stresses also act as a brake on the pigeon pea production [7]. Although some studies have been recently conducted in Benin [5-8] for contribution in pigeon pea genetic improvement, the producers continue to produce local landrace that are sensitive to biotic and abiotic stresses and have many undesirable traits: long cycle, low yield, sometimes bitter taste, very long cooking time [9]. For enhancing pigeon pea cultivation in Benin, some exotic cultivars with high yield potential and some farmers preferred traits were introduced. According to Holland, J., B. [10] introduction of varieties constitutes another approach for crop improvement. The introduced cultivars can be directly adopted for cultivation by the producers or they can be used as parental lines in a breeding program. However, for efficient use of these cultivars it is necessary and indispensable to evaluate their agronomic performances and analyze the effect of genotype x environment interaction in the new growing conditions [11].

Genotype x environment interaction (GEI) analysis is a very important approach in crop breeding [12]. It is the response of each genotype to environmental variations and has been one of the main subjects of study in plant breeding, allowing the generation of different methodologies of genetic improvement and stable genotype recommendations [9]. It has been used on several crop species such as maize [12], wheat [13] and even in pigeon pea [14, 15] to select stable genotypes.

The main objective of the present study is to evaluate the agronomic performance and genotype x environment interaction of 14 exotic pigeon pea cultivars recently introduced in Benin in order to select the potential parents for a pigeon pea breeding program. Specifically, the present study aimed to (1) evaluate the agronomic performance of 14 exotic cultivars of pigeon pea, (2) analyze the effect of genotype x environment on the agronomic performance and (3) Identify stable genotypes in different agro-ecological environments in Benin.

2. Materials and Methods

2.1. Description of the Experimental Sites

Two trials were simultaneously carried out in two different environments. The first environment is the experimental site of the Laboratory of Genetic Resources and Molecular Breeding located on the campus of the University of Abomey-Calavi (UAC), while the second site is located within the International Institute of Tropical Agriculture (IITA). Both sites are located in the same (latitude: N 6° 25' 260" and longitude: E 2° 19' 682") Atlantic Department, characterized by a tropical humid zone marked by high heat and high relative humidity varying between 69 and 97% [16]. In this area the rainfall is bimodal with an annual average of 1200 mm [17]. The average temperature varies between 25 and 29°C. The soils are deep, ferric and red. The climate is subequatorial characterized by four (4) seasons including two (2) rainy seasons from March to June and from September to November. They are separated by two (2) dry seasons: from November to March and from July to August. The fundamental difference between the two environments is based on the soil which is ferralitic and acid on UAC site while the soil is less acid at IITA with a pH of about 6.2. Sowing date was also differed from one site to another. Sowing was carried out at the beginning of the rainy season for UAC trial while at IITA site, sowing has been done late in the middle of the rainy season.

2.2. Plant Material

The plant material used was composed of 14 pigeon pea cultivars. They were obtained from International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in Niger. The gene bank at ICRISAT holds 13,771 pigeon pea accessions from 74 countries and serves as a world repository for genetic resources. Among the 14 cultivars obtained, 12 were Indian accessions, 1 cultivar was Tanzanian accession and 1 was from Puerto Rico. They were very different in seed color and are characterized by the earliness traits contrary to the Beninese cultivars that have a very long maturity cycle [9]. The details of 14 cultivars concerning genotype code, geographic origin and their seed color are summarized in table 1.

Table 1. *List of genotypes, their geographical origin and seed color.*

No.	Genotype	Origin	Main color of seeds
3	PKI 28	India	Greyish white
2	ICP 151	India	Greyish white
3	ICP 7222	India	Red
4	ICPL 84023	India	Brown
5	ICPL 86012	India	Greyish white
6	ICP 11737	India	Red
7	ICP 87	India	Brown
8	MN5	India	Greyish white
9	ICP 12011	Tanzania	Greyish white
10	ICP 6907	Puerto Rico	Red
11	ICP 7119	India	Brown
12	ICP 7187	India	Greyish white
13	ICPL 87119	India	Red
14	ICP 7184	India	Gray White

2.3. Experimental Design and Cultivation Techniques

At both experimental sites the trial was conducted following the Randomized Complete Block Design (RCBD) with 2 replications which is a highly recommended for analysis of genotype x environment interactions [18]. This experimental design has been successfully used to analyze effect of GEI on pigeon pea by Gaur, A., K. et al. [19]. In each replication, experimental plot was consisted of four rows of 1.5 m length with row to row spacing of 1 m and plant to plant of 0.5 m. At all the experimental sites, the sowing was direct and two or three weeks after emergence, the plants were thinned to one plant per hill. Recommended package of practices were adopted to raise a healthy crop and regular plant protection measures were undertaken.

2.4. Data Collection

Data were collected on plants from all elementary plots according to Manyasa, E., O. et al. [15]. Three plants per cultivar were considered and observations were recorded on

11 traits (plant height, number of pods per plant, pod length, pod width, number of seeds per pod, 100-seed weight, seed yield per plant and per hectare, number of days to 50% flowering, number of days to 75% maturity, gap between flowering and maturity). Pod length, pod width, and number of seeds per pod were recorded on ten randomly selected pods from plants in the same plot according to [9]. Descriptions and codes used for all traits are presented in Table 2.

Table 2. *List of quantitative traits assessed, their codes and descriptions.*

Traits	Code	Description
Plant height (cm)	PH	From the ground to the highest point of the canopy
Pods per plant	Po/Pl	Number of pods per plant (at maturity)
Pod length (cm)	PoL	Length of pods in cm (at maturity)
Pod width (cm)	PoW	Width of pods in cm (at maturity)
Seeds per pod	Se/Po	Average number of seeds from 10 randomly selected pods
50% flowering date	FD	Number of days between sowing and 50% flowering of plants
75% Maturity Date	MD	Number of days between sowing and 75% plant maturity
Gap between flowering and maturity	GFM	Number of days between flowering and maturity
Weight of 100 seeds	100SeW	Weight of 100 air-dried seeds (gram)
Grain Yield per plant	GY/Pl	Yield in grams per plant (gram)
Grain Yield per hectare	GY/ha	Yield in kilograms per hectare

2.5. Data Analysis

Data were analyzed using descriptive statistics such as mean, coefficient of variation, minimum and maximum to assess overall variability in the collection for each trait. An analysis of variance (ANOVA) was performed on the data from each experimental site to test the genotype effect by site. A second ANOVA was performed with the combined data. For this analysis, the means of each genotype at each site were used following the method described by Sharma R., J. [20] to highlight the effect of genotype x environment interaction. Genetic parameters such as genotypic variance, environmental variance and variance of genotype x environment interaction were used to estimate the broad sense heritability of the different traits. GEI has also been studied by the analysis of additive effects and multiplicative interaction (AMMI) which is a robust multi-variate method for multi-environment trials [21, 22]. To analyze the stability of the genotypes, stability indices such as Wricke's ecovalence (W) [23], Shukla's variance (S) [24] and genotypic superiority index (P) [25] were calculated. All the analyses as well as the various stability parameters calculated are carried out with the R software version 4.0.1.

3. Results

3.1. Phenotypic Divergence and Agronomics Performance of Cultivars

The agronomics performance of the cultivars in the collection evaluated by descriptive statistics followed by analysis of variance (ANOVA) revealed a significant difference between the 14 cultivars for all agronomic traits studied (Table 3).

Table 3. *Descriptive statistics and significance level of ANOVA test for the 11 agronomic traits.*

Traits	IITA					UAC				
	Min	Max	Mean	CV	F test	Min	Max	Mean	CV	F test
PH	60.00	220.00	112.27	35.72	***	44.0	260.0	121.9	52.94	***
Po/Pl	20.0	399.0	114.3	78.52	***	25.0	380.0	148.8	61.60	***
PoL	3.800	5.600	5.025	11.04	**	4 200	6 500	5,193	13.36	***
PoW	0.9000	1.0000	0.9700	4.27	***	0 9000	1 3000	1 0571	10.75	***
Se/Po	2.9000	4.2000	3.7536	9.71	***	3,000	5,000	4.040	11.71	***
FD	55.00	88.00	75.86	9.86	***	50.0	113.0	88.07	18.02	***
MD	132.00	159.00	138.21	5.90	***	126.00	161.00	146.71	6.92	***
GFM	54.00	88.00	63.29	14.23	*	43.00	84.00	58.64	18.06	***
100SeW	6.620	12.010	9.506	15.83	***	6 900	12 110	9 553	16.74	***
GY/Pl	5.74	144.71	40.19	79.32	***	8.40	135.70	54.77	65.29	**
GY/ha	78.5	1476.3	413.7	78.27	***	85.5	1384.3	558.4	65.35	**

*** Very highly significant, **highly significant, * significant, F-test: Fisher exact test, CV: Coefficient of variation, Min: Minimum, Max: Maximum.

At the IITA site the highest coefficient of variation was observed for the trait "grain yield per plant" (CV=79.32%). This trait varied between 5.74 g (ICP 7119) and 144.71g (ICPL 87119) with an average of 40.19g per plant. At the UAC site, grain yield per hectare was the most variable character (CV=65.35%) followed by grain yield per plant (CV=65.29%). Grain yield per hectare varied from 85.5 kg/ha (ICP 7119) and 1384.3 kg/ha (ICP 87) for an average of 558.4 kg/ha. The highest values for grain yield per hectare were observed for the Indian cultivars ICPL 87119 and ICP 87 at IITA and UAC sites, respectively. High variation was also observed for the traits "plant height" and "number of pods per plant" (CV>20%) at both sites. Plant height ranged from 44 to 260 cm for a mean value of 112.27 at IITA while, it ranged from 44 to 200 cm for mean value of 121.9 cm at UAC. For all of the 14 cultivars the mean values of number of pods per plant were 114.3 and 148.8 at IITA and UAC sites, respectively. The cultivar with the greatest height (220 cm) at IITA is ICPL 87119 while at UAC, the cultivar ICP 6907 (Puerto Rico) has the greatest height. These cultivars also had the highest number of pods at both sites. Moderate variation (CV< 20%) was observed for the rest of studied traits.

3.2. Analysis of Genotype x Environment Interaction and Heritability Estimation

The effects of genotype, environment and genotype x environment interaction on the 11 traits are reported in Table 4. The results showed that the effects of all these three factors were significant for all the traits.

Table 4. *Estimation of G x E interaction and heritability for the 11 agronomic traits.*

	Genotype		Environment		GEI		VG	VGXE	VE	H^2
Traits	Mean square	F Test	Mean square	F Test	Mean square	F Test				
GY/ha	288649	***	293.159	***	163501	***	31287.25	71967.27	19565.88	0.43
GY/Pl	2801.8	***	2975.9	***	1563.7	***	309.55	688.62	186.39	0.44
100SeW	9.8933	***	0.0297	**	0.1116	***	2.445	0.054	0.003	0.98
GFM	126.91	***	301.78	**	220.94	***	0.00	74.53	24.85	0.01
MD	111.65	***	1011.50	***	225.31	***	3.21	8.06	7.21	0.01
FD	359.07	***	2088.64	***	257.72	***	25.33	123.59	10.53	0.28
Se/Po	0.42	***	1.17	***	16.05	***	0.03	0.13	0.01	0.34
PoW	0.01	***	0.01	***	0.08	***	2.14	2.26	1.42	0.65
PoL	0.69	***	0.39	*	0.80	***	0.00	0.34	0.06	0.01
Po/Pl	24377.5	***	16594.6	***	9263.5	***	3778.52	4507.67	248.24	0.61
PH	9663.9	***	1306.6	**	2081.7	***	1895.54	983.30	115.11	0.78

*** very highly significant, **highly significant, * significant; F-test: significance test, H^2: Heritability, VG: Genotypic variance, VE: Environmental variance, VGXE: Genotype x environment interaction variance

Although all the 11 traits were influenced by environment factors, the heritability value was high for some traits. It varied between 0.01 and 0.98. The highest heritability value (0.98) was observed for the trait "100 seeds weight" while the traits like "gap between flowering and maturity", "length of pods" and " maturity date " presented the lowest heritability value (0.01). Traits such as plant height (0.78), number of pods per plant (0.61) and pod width (0.65) had high heritability values indicating that these traits are highly heritable. A moderate value of heritability was observed for the characters "grain yield per plant" and "grain yield per hectare". They are estimated at 0.44 and 0.43 respectively. Traits such as flowering date and number of pods per plant had a relatively moderate heritability value, estimated at 0.28 and 0.34, respectively.

3.3. AMMI Analysis of G x E interaction and Genotype Specific Adaptability

The AMMI analysis across the two environments showed that the effect of GEI was significant for all traits (Table 5). It was highly significant (P < 0.01) for the traits plant height, number of pods per plant, yield per plant and flowering date while for the other traits (pod length, pod width, number of seeds per pod, maturity date, gap between flowering and maturity, 100-seed weight and yield in kg/ha), the effect was significant. The principal component analysis associated with the AMMI analysis showed that, the first two principal components of the interaction (IPCA1 and IPCA2) were significant for all traits, and they explained almost 100% of the total variance.

Table 5. *Analysis of variance and decomposition of the G x E interaction using AMMI analysis.*

Traits	Mean Square G	Mean Square E	Mean square GxE	ICPA1		ICPA2	
				Mean Square	Var Exp	Mean Square	Var Exp
PH	9663.9 ***	473.3**	773.6**	1811.5 ***	0.90	181.8 3*	0.07
Po/Pl	24377.5 ***	5628.4**	3258.6**	8047.0 ***	0.94	278.5*	0.02
Se/Po	5 266**	0.245**	0.87*	0.99***	0.86	0.05*	0.13
PoL	0.69*	0.13*	0.31*	0.70***	0.86	0.12***	0.13
Pow	0.01***	0.02***	0.52*	0.01***	1.00	0.00***	0.00
FD	359.07***	706.74***	92.66**	223.46***	0.92	13.46*	0.04
MD	111.65*	340.64 *	80.01*	196.42***	0.94	10.33*	0.04
GFM	126.91*	100.83*	91.47*	197.25***	0.82	40.09**	0.14
100SeW	9.89***	0.09*	0.08*	0.09***	0.95	0.01*	0.03
GY/Pl	2801.85***	1101.48*	646.62**	1355.52***	0.80	358.88***	0.18
GY/ha	288649***	109477*	67643*	141724***	0.80	37309***	0.18

*** very highly significant, **highly significant *significant, G: Genotype, E: Environment, Var Exp: variance explained, ICPA: interaction principal components.

The specific adaptabilities of the genotypes to the different environments were also deduced from the AMMI analysis. The biplots on Figure 1 showed the specific adaptabilities of genotypes across the two environments. For grain yield per hectare trait, genotypes ICPL86012 and ICP87 showed a specific adaptation to UAC while genotypes ICP7222 and ICP151 are specific to IITA. For flowering date, genotypes MN5, ICP12011, ICP87 and ICP7187 are more adapted to UAC and genotypes ICPL84023 and ICP11737 are more adapted to IITA. For the number of pods per plant genotypes ICP87, ICP6907 and ICPL86012 are better adapted to UAC. The results showed for number of seeds per pod that genotypes IC7222 and MN5 are more adapted to IITA than genotypes ICP87, ICPL86012, ICPL84023 and ICP28 which are more adapted to campus. Genotype ICP7184 is more adapted to campus than genotypes ICP6907, ICPL 84023, ICP7187, and ICP7222 which are more adapted to IITA for the trait 100-seed weight.

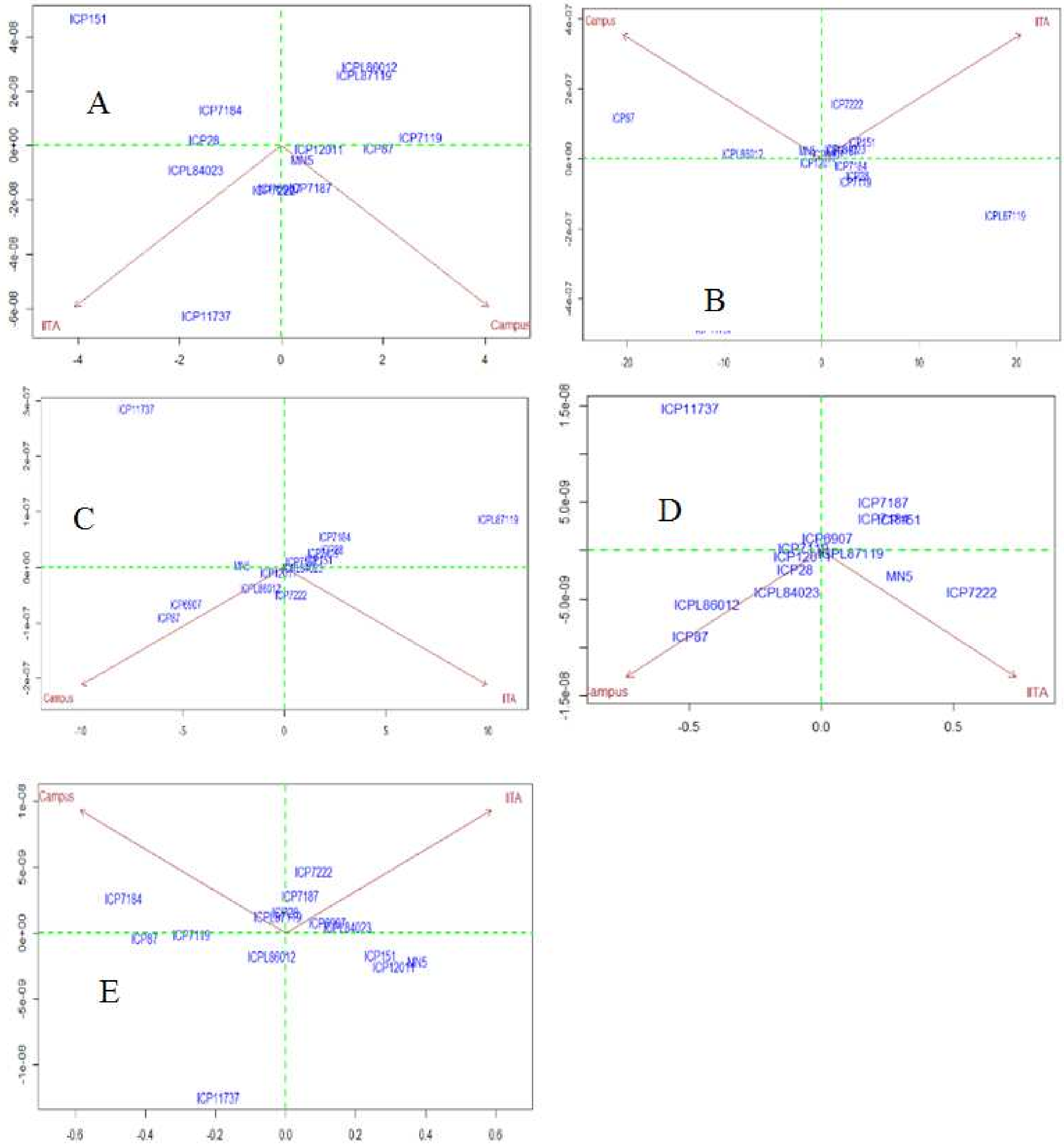

Figure 1. Genotypes adaptability across the environments for flowering date (A), yield per hectare (B), number of pods per plant (C), number of seeds per pod (D), and 100 seeds weight (E).

3.4. Agronomic Performances Stability Analysis

Flowering date and grain yield per hectare are two characters retained for stability analysis. For these two characters, mean values and values of the three stability indexes for each cultivar are shown in Table 6.

Table 6. *Stability parameter values for seed yield and flowering date.*

Genotype	Mean value	Grain Yield per ha			Mean value	Flowering Date		
		P	S	W		P	S	W
ICP 7119	101.67	8.83	7.63	123.34	92.5	5	684.5	307.16
ICP 7222	231.28	7.2	295	7247	83	17.76	60.5	0.73
ICP 12011	251.88	7.02	12669.93	1.04	86	10.25	180.5	23.02
ICP 84023	308.26	6.31	57.83	61.26	77.5	36.25	4.5	115.73
ICP 151	346.9	5.87	100.37	179.57	65	90.62	242	585.3
PKI 28	362.53	5.7	29.97	143.12	75.25	40.65	1.12	87.3
ICP 7187	384.96	5.48	117.85	46.23	92.25	4.1	153.12	13.96
ICP7184	447.73	4.83	1.49	96.92	74.25	41.35	1.12	57.39
ICP 11737	527.06	4.75	20718.45	1245.04	70.5	53.45	0.5	94.04
MN5	526.54	4.19	2226.68	21.99	93	3.82	128	7.16
ICP87	847.01	3.38	57,216.64	4278.38	72.25	40.15	435.12	149.39
ICPL 86012	696.77	3.14	13,119.2	675.38	84	13.72	392	124.59
ICP 6907	667.53	2.96	629.27	5.28	93	4.92	72	0.02
ICPL 87119	1103.91	1.01	25,411.32	3677.44	88.5	7.25	364.5	109.3

Based on Shukla's stability index, the cultivars ICP7119, ICP7184, ICP28, ICP151 and ICP84023 are the most stable for yield while for flowering date the stable genotypes are ICP84023, ICP7184, ICP28, ICP11737, ICP6907 and ICP7222. For Wricke's ecovalence, which describes the stability of a genotype as the contribution of each genotype to the sum of squares of the genotype x environment interaction, the cultivars with less fluctuations across environments are ICP12011, ICP6907, ICP84023, ICP7187, ICP7184 and MN5 for yield. Concerning flowering date, the genotypes ICP7222, ICP6907, MN5, ICP12011, ICP28, ICP7187 and ICP7184 were stable on both environments. The genotypic superiority index (P) is an estimate of genotype adaptability over a range of environments. According to this index genotypes ICP7187, MN5, ICP6907 and ICP7119 are considered stable for flowering date and genotypes ICP7184, ICP11737, MN5, ICP87, ICPL86012, ICP6907 and ICP87119 are the most stable for grain yield. By considering the value of the three stability indexes together, the results revealed that the cultivar ICP7184 is the most stable for grain yield and ICP6907 is the most stable for flowering date.

4. Discussion

The agronomic traits are generally complex traits mostly influenced by the environment. According to Kucek, L., K. et al. [13], for any crop breeding for agronomic traits genotype x environment interactions must be taken into account in order to create varieties with stable performance. Here we reported the results of agronomic performances and genotype x environment interactions of newly introduced pigeon pea cultivars in Benin in order to select potential parents to be used in pigeon pea breeding program of Benin.

The 14 cultivars of the collection evaluated were divergent for all agronomic traits. This result indicated that there is a great phenotypic variability in the collection. The high phenotypic variability observed in the collection can be explained by the high number of Indian accessions in the collection. Indeed, India is the center of domestication and diversification of pigeon pea [2]. Based on the descriptive statistics, the results showed that the collection was composed of very early cultivars. The mean value of flowering date in the collection was about 88.07 days in contrast to local pigeon pea landraces of Benin which were very late cultivars with more than 185 days for flowering [9, 26]. In addition to be early cultivars, they were very productive. The mean value of grain yield per hectare in the collection is about 600 kg/ha and it can reach 1476.3 kg/ha for some cultivars. These two good agronomic characteristics that are earliness and high productivity observed in the collection satisfy farmers' preference criteria in pigeon pea production [5]. The 14 exotic cultivars could be therefore proposed to the growers for a direct adoption and cultivation. They can be also exploited to improve the undesirable characteristics of local landraces.

Although the 14 exotic cultivars presented good agronomic performance, it is essential to verify if this performance is attributed to genetic or environmental factors as suggested by Ndiaye, M. et al. [27]. Since phenotype is the sum of genotype, environment, and their interactions, it is paramount to analyze the effect of genotype x environment interaction of our plant material. The analysis of variance done on the combined data of the two environments revealed a highly significant effect of the genotype x environment interaction for the 11 traits studied. This high significance of genotype x environment interaction was confirmed by the analysis of additive effects and multiplicative interaction (AMMI) which is the most recommended multivariate method for multi-environment trials [21]. This finding corroborates that of Wamatu J., N. and Thomas, E. [28] who demonstrated the influence of genotype x environment interaction on the yield of 10 pigeon pea cultivars in Kenya. Nevertheless, despite this high influence of genotype x environment interaction observed, some traits such as plant height, pod width, number of pods per plant and 100-seed weight showed high heritability value ($H^2 > 0.5$). These traits are therefore highly heritable and could easily use in local pigeon pea cultivar breeding programs as suggested by Manyassa E., O. [15].

The possible complications that may arise from G x E interactions can be limited by identifying genotypes with stable performance under fairly diverse growing conditions [29]. As the selection of stable genotypes varied according to the stability index, three different stability indexes were used here to identify the most stable genotypes. Therefore, by using the indexes that are the genotypic superiority index (P), Wrike's ecovalence (W), and Shukla's stability index (S) as described by Abderrahmane, H. [30], ICPL84023 and ICP 7184 were identify as the most stable genotypes for grain yield in kg/ha. Although these two cultivars were the most stable genotypes for grain yield, they were not the high yielding cultivars in the collection. This result is line with the finding of Menad, A. et al. [31] who reported that yield stability is independent of yield values, and varieties with high yielding are generally relatively unstable while the opposite is generally true for medium and low yielding genotypes.

5. Conclusion

The aim of the present study is to identify pigeon pea cultivars with stable agronomic performance through an evaluation of genotype x environment interactions. The results obtained are very interesting. A large phenotypic divergence exists in the collection. The 14 exotic cultivars are all different for the 11 traits. The collection is dominated by short-cycle genotypes that can be used as parents to improve local Beninese varieties that are generally long-cycle. Moreover, the cultivars evaluated are very productive and could be adopted directly by producers. However, genotype x environment interaction analyses showed high significant effect on all traits. Cultivars responded differently to the two environments tested, but some genotypes showed environment-specific adaptabilities. Based on the different stability indexes, the genotypes ICP7184 and IC6907 showed the best stable performance for the trait productivity and flowering date respectively. Our findings are important and can be used to accelerate pigeon pea production in Benin. The different genotypes evaluated could be used as potential parents in genetic improvement programs of local pigeon pea landraces.

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