Green Farming Vol. **6** (1) : 1-4 ; January-February, 2015 **Research Paper**

Evaluation for early seedling vigour of hybrids and varieties of pigeonpea [*Cajanus cajan* (L.) Millsp.]

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Received : 24 July 2014 ; Revised accepted : 10 December 2014

ABSTRACT

The research was conducted at Parbhani, Maharashtra, India during *kharif* 2011and 2012 to evaluate hybrid and varieties of pigeonpea for early seedling vigour and its related traits under greenhouse condition. The experimental material consists of three medium duration hybrids (ICPH 2671, ICPH 2740, and ICPH 3762) and three medium maturing varieties (BDN 711, BSMR 736, and Asha). Results revealed that hybrids recorded significantly higher rate of germination (97.58%), longer radicle length (16.75 cm), wider leaf area (177.70 cm^2), more chlorophyll content (37.35), higher seedling dry weight (4.6 g) and greater seedling vigour index (4139.08) as compared to varieties (91.9%, 11.85 cm, 106.27 cm^2, 32.81, 3.67 g and 3937.28, respectively). Genotype × environment (G × E) interaction found highly significant for all the traits except leaf area and seedling vigour index. Among G × E combinations, G_3E_2 (ICPH 3762 in 2012) noted longer radicle (21.78 cm), wider leaf area (189.9 cm^2), more chlorophyll content (38.64) and highest seedling dry weight (5.84 g). These findings proved that hybrids had better germination percentage, uniform plant stand, longer radicle, and better seedling vigour index, an indication of producing higher seed yield over the varieties.

Key words : *Environment, Hybrids, Pigeonpea, Seedling vigour, Varieties.*

INTRODUCTION

Pigeonpea [*Cajanus cajan* (L.) Millsp.] is an important rainy season pulse crop of tropical and sub-tropical regions. It has been observed that despite of significant increase in national area and production, the productivity of pigeonpea remains constant (774 kg/ha) over the last five decades (Sharma *et al.,* 2013). Bharathi and Saxena (2012) reported that cultivation of high yielding pigeonpea hybrids may contribute in overcoming the productivity constraints due to their better germination, establishment of uniform plant stand, faster seedling growth and high yield potential.

Ellis (1992) defined seedling vigour as "It is the sum total of those properties of the seed which determine the potential level of activity and performance of the seed or seed lot during germination and seedling emergence". However, seedling emergence and growth performance in the field indicates the emergence ability of seedlings under unfavorable environ-mental conditions. Vigour may influence growth and yield. Therefore, poor vigour will reduce yields in two ways: first, deceased emergence may lead to insufficient populations; and secondly, those seedlings which do emerge grow more slowly and under some circumstances, this can affect final yield, even when anticipated non-emergence is compensated by increased sowing rates (Roberts and Bonsu, 1988).

Seed vigour is a function of both genotype and environment interaction; accordingly, improvements are feasible through breeding as well as through agronomic practices (Roberts and Bonsu, 1988). By considering the importance of germination, seedling growth and seedling vigour in final yield of pigeonpea, the study aimed to understand the variances among hybrids and varieties.

MATERIALS AND METHODS

The research was carried out at Parbhani (19^{0}16'N, 67^{0}47'E, 409.0 MSL), Maharashtra, India under greenhouse condition during *kharif* 2011 (E_1) and 2012 (E_2). The experimental material comprised of three medium duration hybrids (ICPH 2671, ICPH 2740, and ICPH 3762) and three medium duration varieties (BDN 711, BSMR 736, and Asha). Likewise, BSMR 736 and Asha, were used as control. Pigeonpea cultivars were planted in pot containing soil, sand and farm yard manure in 1:1:1 proportion. Dimension of the pot was 18 cm diameter and 35 cm long filled with 3.5 kg dry soil media in each pot to create uniform bulk density. Seeds were treated with tetra methyl thiuram disulphide @ 2.5 g/kg before sowing to avoid fungal diseases. For uniform germination watering at field capacity was made in each pot prior to sowing.

The experiment was laid out in completely randomized design (CRD) with four and nine replications in Kharif 2011 and

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2012, respectively. Each cultivar consists of ten pots/replication. Data on radicle length (cm), plumule length (cm), leaf area (dm^2), chlorophyll content, seedling dry weight (g) and seedling vigour index (I) were recorded after 30 days of sowing on the basis of five uniform plants in each replication. The chlorophyll content in leaves was measured from the third leaf of the plant using SPAD (Special Products Analysis Division) meter. Automatic leaf area meter were used to record leaf area. Seedling dry weight was determined with leaf dry weight & stem dry weight (oven dried at 60°C for at least 48 hrs.). Seedling vigour index (I) is estimated by using following formula :

Seedling vigour index (I) = Germination (%) x [radicle length (cm) + plumule length (cm)]

The data were subjected to statistical analysis using SAS version 9.2 (SAS/STAT, 2008) to understand the differences between the hybrids and varieties of pigeonpea in terms of seedling vigour and its related traits.

RESULTS AND DISCUSSION

Germination : The effect of environment did not influence the germination (%) of pigeonpea however, significant variation was observed between the cultivars (**Table 1**). Hybrids and varieties were significantly different across the environments (**Table 2**) where E_2 (2012) delivered the highest rate of germination at 95.02%.

Among the genotypes, hybrids showed higher rate of germination (97.58%) as compared to varieties (91.9%) which corresponds to the findings of Bharathi and Saxena (2012). **Table 3** likewise revealed that ICPH 2671 recorded the highest rate of germination (99.53%) while BDN 711 had the lowest germination percentage (82.56) which is similar to the findings of Mercer *et al.* (2006).

Genotype × environment (G×E) interaction found significantly different for germination (Table 1) where G_2E_2 (ICPH 2740 in 2012) recorded significantly higher germination rate (99.56 %) followed by G_1E_1 [ICPH 2671 in 2011 (99.5%)] while G4E1 (BDN 711 in 2011) showed the lowest (81%) (**Table 4**).

Radicle length (cm) : Highly significant variation for radicle length was observed due to environment effect (Table 1). Longer radicle was recorded in E_2 (17.57 cm) than E_1 (11.23 cm) (Table 2).

The effect on genotypes revealed highly significant differences for radicle length (Table1) wherein hybrids recorded longer radicle (16.75 cm) as compared to varieties (11.85 cm) across the environments (Table 3) which corresponds to the findings of Bharathi and Saxena (2012) due to more reserved food material in the seed embryo of hybrids that contributed towards the development of roots.

Out of six genotypes, ICPH 3762 recorded longer radicle (17.76 cm) followed by ICPH 2740 (17.12 cm) while BDN 711 had shorter radicle (11.26 cm). All the hybrids recorded significantly longer radicle over the control (BSMR 736 - 12.31 cm and Asha - 11.97 cm). Thakare and Mula *et al.* (2013a) reported that pigeonpea hybrids had longer radicle than varieties.

The interaction between G × E was highly significant as shown in **Table 4**. Among G × E interaction combinations, G_3E_2 (ICPH 3762 in 2012) showed longer radicle (21.78 cm) closely followed by G_2E_2 at 21.07 cm (ICPH 2740 in 2012) while G_4E_1 (BDN 711 in 2011) produced shorter radicle (8.80 cm) which conforms to the findings of Thakare and Mula *et al.* (2013b).

Plumule length (cm) : A highly significant variation was observed for plumule length on the effect of environment (Table 1) where highest plumule length was recorded in E_2 (34.75 cm) than E_1 (21.57 cm) (Table 2).

Table 1. Analysis of variance (ANOVA) for various seedling vigour related traits for across the environments

Source	Df	Germination (%)	Radicle length (cm)	Plumule length (cm)	Chlorophyll content	Leaf area (cm^2)	Seedling dry weight (g)	Seedling vigour index (I)
Environment	1	NS	HS	HS	HS	HS	HS	HS
Genotypes	5	HS	HS	HS	HS	HS	HS	HS
Genotype × Environment	5	S	HS	HS	NS	S	HS	NS
Hybrids × varieties in 2011	18	HS	HS	HS	HS	HS	HS	HS
Hybrids × varieties in 2012	48	HS	HS	HS	HS	HS	NS	HS
Hybrids × varieties (across the /years)	26.4	HS	HS	HS	HS	HS	HS	HS

Note : HS – Highly significant (at 1%), S-Significant (at 5%), NS- Non-significant

Table 2. Mean performance for individual trait in each environment

Source	Germination (%)	Radicle length (cm)	Plumule length (cm)	Chlorophyll content	Leaf area (cm^2)	Seedling dry weight (g)	Seedling vigour index (I)
E_1 (2011)	94.46^a	11.23^b	21.57^b	133.51^b	34.54^b	3.51^b	3103.14^b
E_2 (2012)	95.02^a	17.57^a	34.75^a	150.45^a	35.61^a	4.76^a	4973.22^a

Note : Means followed by the same letter in a column (a-b) do not differ significantly at P = 0.05

Table 3. Performance of pigeonpea genotypes for various seedling vigour related traits across the seasons

Source	Germination (%)	Radicle length (cm)	Plumule length (cm)	Chlorophyll content	Leaf area (cm^2)	Seedling dry weight (g)	Seedling vigour index (I)
Hybrids							
ICPH2671	99.53[a]	15.97[b]	25.01[c]	170.51[b]	35.69[b]	4.43[b]	4079.95[a]
ICPH2740	97.65[ab]	17.12a	25.42[c]	185.50a	37.91[a]	4.49[b]	4153.12[a]
ICPH3762	95.56[b]	17.76a	25.85[c]	177.07[ab]	38.45[a]	4.88[a]	4184.18[a]
Mean	**97.58**	**16.75**	**25.43**	**177.70**	**37.35**	**4.6**	**4139.08**
Varieties							
BDN 711	82.56[c]	11.26[d]	29.44[b]	88.21[d]	31.96[d]	3.16[d]	3378.24[b]
BSMR736 (control)	96.78[ab]	12.31[c]	31.44[a]	113.56[c]	32.98[c]	3.85[c]	4221.15[a]
Asha (control)	96.36[b]	11.97[cd]	31.78[a]	117.03[c]	33.48[c]	4.01[c]	4212.45[a]
Mean	**91.9**	**11.85**	**30.87**	**106.27**	**32.81**	**3.67**	**3997.28**

Note : Means followed by the same letter in a column do not differ significantly at *P* = 0.05

Highly significant variation was observed among genotypes across the environments (Table 1) whereby the longest average plumule was recorded in varieties (30.87 cm) than hybrids (25.43 cm) as shown in Table 3 which is in conformity to the findings of Bharathi and Saxena (2012). Among the genotypes, Asha had the longest plumule (31.78 cm) as compared to hybrids while BDN 711 (29.44 cm) is the lowest which corresponds to the findings of Thakare and Mula *et al.* (2013a and 2013 b).

Highly significant difference was recorded in the G × E interaction (Table 1) where G6E2 (Asha in 2012) showed the longest plumule (39.59 cm) while G2E1 (ICPH 2740 in 2011) was the lowest (19.21 cm) (Table 4).

Leaf area (cm^2) : The effect of environment disclosed highly significant differences for leaf area among the genotypes (Table 1) where the highest leaf area was recorded in E_2 (150.45 cm^2) than E_1 (133.51 cm^2) as shown in Table 2.

Leaf area significantly differed due to genotypic effect. Between hybrids vs. varieties, a highly significant disparity was observed across the environments wherein hybrids noted higher leaf area (177.70 cm^2) over varieties (106.27 cm^2) as indicated in Table 3 which conforms to the findings of Thakare and Mula et al. (2013a and 2013b). Among the genotypes, ICPH 2740 obtained wider leaf area (185.50 cm^2) while BDN 711 exhibited lesser leaf area (88.21 cm^2) as revealed in Table 3.

Genotype × environment (G × E) interaction found non-significant for leaf area. However, Table 4 revealed that wider leaf area was obtained by ICPH 3762 in 2012 (G_3E_2) (188.10 cm^2) whereas BDN 711 in 2011 (G_4E_1) had minimum leaf area (84.15 cm^2).

Chlorophyll content : There was a significant variation on chlorophyll content due to the effect of environment (Table 1) where higher chlorophyll content was recorded in E_2 (35.61) than E_1 (34.54) (Table 2).

Among the genotypes, hybrids recorded superior chlorophyll content (37.35) as compared to varieties (32.81) across the environments (Table 3). Amongst genotype, ICPH 3762 (38.45), ICPH 2740 (37.91) and ICPH 2671 (35.69) had higher chlorophyll content than varieties which agrees to the findings of Thakare and Mula *et al.* (2013a and 2013b).

Genotype × environment interaction showed significant differences (Table 1) where G3E2 (ICPH 3762 in 2012) had the highest chlorophyll content (38.64) followed by G3E1 [ICPH 3762 in 2011 (38.25)] while G4E1 (BDN 711 in 2011) has the least chlorophyll content (31.25).

Seedling dry weight (g) : Seedling dry weight showed highly significant variation due to environmental effect (Table 1) which revealed that E_2 (4.76 g) recorded the highest seedling dry weight as compared to E_1 (3.51 g) (Table 2).

Between hybrids and varieties (Table 3), hybrids were found to have higher mean seedling dry weight (4.6 g) over the varieties (3.67 g) which is in conformity to the results of Bharathi and Saxena (2012). Among genotypes, ICPH 3762 recorded highest seedling dry weight (4.88 g) however, BDN 711 had the lowest seedling dry weight (3.16 g) which corresponds to the findings of Saxena *et al.* (1992) and Thakare and Mula *et al.* (2013 b).

Genotype × environment interaction found significant whereby G_3E_2 (ICPH 3762 in 2012) recorded highest seedling dry weight (5.84 g) followed by G_2E_2 [ICPH 2740 in 2012 (5.56 g)] and G_1E_2 [ICPH 2671 in 2011(5.23 g)] as shown in Table 4 and **Fig. 1**.

Seedling vigour index : Highly significant differences for seedling vigour index was observed on the effect of environmental (Table 1) where E_2 recorded higher seedling vigour index (4973.22) as compared to E_1 (3103.14) (Table 2).

Among genotype effect, seedling vigour index showed highly significant across the environments. Hybrids exhibited higher seedling vigour index (4139.08) than varieties (3937.28) (Table 3) which coincides to the findings of Bharathi and Saxena (2012). BSMR 736 and Asha recorded highest seedling vigour

Table 4. Genotype × environment interaction for the various seedling vigour related traits

Interactions	Germination (%)	Radicle length (cm)	Plumule length (cm)	Chlorophyll content	Leaf area (cm^2)	Seedling dry weight (g)	Seedling vigour index (I)
G_1E_1	99.5^{a}	12.45^{e}	20.58^{fg}	160.10	34.25^{c}	3.63^{c}	3287.83
G_2E_1	97.75^{ab}	13.18d^{e}	19.21^{g}	182.90	37.75^{ab}	3.43^{cd}	3166.63
G_3E_1	94^{b}	13.75^{cd}	19.93^{fg}	164.23	38.25^{ab}	3.93^{c}	3168.75
G_4E_1	81^{c}	8.80^{h}	21.83^{f}	84.15	31.25^{e}	3.00^{d}	2479.85
G_5E_1	98^{a}	10.05^{f}	23.87^{e}	102.20	32.50^{de}	3.48^{cd}	3323.55
G_6E_1	96.5^{ab}	9.13^{gh}	23.98^{e}	107.48	33.25^{cd}	3.63^{c}	3192.25
G_1E_2	99.56^{a}	19.49^{b}	29.44^{d}	180.91	37.13^{b}	5.23^{a}	4872.07
G_2E_2	97.56^{ab}	21.07^{a}	31.62^{c}	188.10	38.08^{ab}	5.56^{a}	5139.62
G_3E_2	97.11^{ab}	21.78^{a}	31.78^{c}	189.92	38.64^{a}	5.84^{a}	5199.60
G_4E_2	84.11^{c}	13.72^{cd}	37.06^{b}	92.28	32.67^{de}	3.31cd	4276.62
G_5E_2	95.56^{b}	14.58^{c}	39.00^{a}	124.91	33.46^{cd}	4.23b	5118.76
G_6E_2	96.22^{b}	14.81^{c}	39.59^{a}	126.58	33.70^{cd}	4.40b	5232.64

Note : Means followed by the same letter in a column do not differ significantly at P = 0.05
E_1 = 2011, E_2 = 2012 G_1- ICPH 2671, G_2-ICPH 2740, G_3- ICPH3762, G_4- BDN 711, G_5- BSMR 736, and G_6- Asha

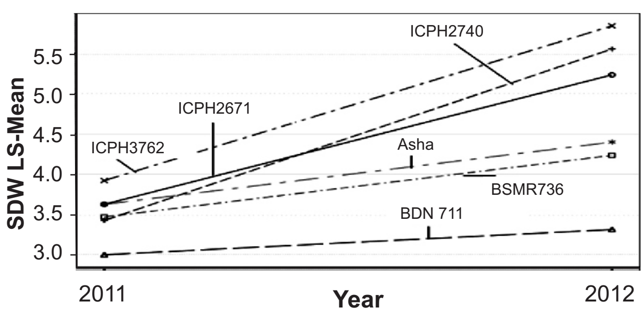

Fig. 1. Mean performance of pigeonpea genotypes for seedling dry weight in each environment

index (4221.15 and 4212.45, respectively) while in hybrids, ICPH 3762 had the highest seedling vigour index (4184.18) followed by ICPH 2740 (4153.12) and ICPH 2671 (4079.95) while BDN 711 recorded the lowest seedling vigour index (3378.24) which is in conformity to the findings of Thakare and Mula *et al.* (2013b).

Genotype × environment interaction found not significant however, G6E2 (Asha in 2012) interaction recorded the highest seedling vigour index (5232.64) while G4E1 (BDN in 2011) had lesser seedling vigour index (2479.85) as shown in Table 4.

CONCLUSION

The results of the study indicated that hybrids had higher rate of germination (97.58%), longer radicle (16.75 cm), wider leaf area (177.70 cm^2), more chlorophyll content (37.35), higher seedling dry weight (4.6 g) and greater seedling vigour index (4139.08) as compared to varieties (91.9%, 11.85 cm, 106.27 cm^2, 32.81, 3.67 g and 3937.28, respectively). However, Asha (control) had the highest seedling vigour index (4212.45) but not significantly different with other genotypes. Among G × E interaction combinations, G_3E_2 (ICPH 3762 in 2012) had highest radicle (21.78 cm), wider leaf area (189.9 cm^2), more chlorophyll content (38.64) and highest seedling dry weight (5.84 g).

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