JFL

Journal of Food Legumes 34(1): 51-56, 2021

IPA 15-2 (Sharada): A high yielding, wilt and sterility mosaic disease resistant pigeonpea cultivar for North East Plain Zone

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Received: March 02,2021

Accepted: June 06, 2021

Handling Editor: Dr. Meenal Rathore, ICAR-Indian Institute of Pulses Research Kanpur

ABSTRACT

Development of improved cultivars with enhanced resistance/tolerance is an indispensable process to improve the productivity in pigeonpea. Newly released long duration pigeonpea variety IPA 15-2 (Sharada) was developed by crossing diverse parents' *viz*., NDA 1 and MAL 13. The generation advancement was monitored through pedigree breeding method. The female parent NDA 1 is compact in growth habit with resistant reaction to sterility mosaic disease (SMD). While, the male parent MAL 13 is spreading and resistant to wilt disease. The variety IPA 15-2 (Sharada) was subjected to three years rigorous testing for yield stability and disease resistance under All India Coordinated Research Project on pigeonpea during 2017-18 to 2019-20. The results revealed that the weighted mean of three years grain yield over six test location was 2266 kg/ha. However, the centre Varanasi recorded highest yield of 2998 kg/ha. The variety IPA 15-2 (Sharada) offers 23.47% higher yield superiority over the national check variety Bahar and 24.38% over zonal check IPA 203 (Prakash). It is resistant to wilt (15.11%) and sterility mosaic disease (15.62%). Keeping this in view the committee on Release of Crop Variety to Central Sub-Committee on Crop Standards Notification and Release of Varieties has recommended IPA 15-2 (Sharada) for cultivation in North East Plain Zone comprising the states of Uttar Pradesh, Bihar, Jharkhand and West Bengal.

Key words: High yield, North East Plain Zone, Sterility mosaic disease resistance, Pigeonpea, Variety

INTRODUCTION

Pigeonpea [*Cajanus cajan* (L.) Millsp], an important multi–purpose grain legume crop of rainfed agriculture, is globally cultivated in about 82 countries in an area of 5.61mha with a production of 4.42mt and an average productivity of 788kgha^{-1} (FAOSTAT, 2019). India is the global leader in terms of total acreage under cultivation (4.3 mha), production (3.83 mt), yield (890 kg/ha), processing and consumption of pigeonpea in 2019-20 (http://agricoop.gov.in).

Pigeonpea is an integral part of human diet as a source of plant protein among majority of the Indian households. It is grown as sole crop or inter crop in varying agro-eco systems as a means to supply food for humans, fodder and feed for animals, fuel wood for rural households, soil binder to protect soil erosion and as border crop to protect the main crop. Development of pigeonpea varieties with improved seed yield and resistance to different biotic and abiotic stresses stood at the highest priority to the breeder ever since the organized pigeonpea breeding initiated under All India Coordinated Pulses Improvement Project (AICPIP) in 1967. The current elastic population growth of 1.2% (www.thehindubusinessline.com, 2019) in India had created increased demand on limited available resources that are depleting progressively. The prime production factors like land, water and climate is under gradual degradation and posing threat to loss of biodiversity (FAO, Land and water resource planning, 2018). Such alarming situation requires rational approaches to conserve and efficiently use available resources that sustain and enhance productivity and maintain ecosystem resilience.

Pigeonpea is the favorite crop of rainfed semi-arid farming system of India. It is being cultivated in five different zones namely (i) North East Plain Zone (Uttar Pradesh, Bihar, West Bengal, Jharkhand); (ii)North West Plain Zone (Punjab, Haryana, Uttarakhand, Delhi); (iii)Central Zone (Madhya Pradesh, Maharashtra, Rajasthan, Chhattisgarh); (iv) South Zone (Karnataka, Telangana, Andra Pradesh, Tamil Nadu) (v) North Hilly Zone (Tripura, Manipur, Nagaland).

The rich fertile soil of Indo gangetic plains and hot-humid climatic conditions of North East Plain Zone (Uttar Pradesh, Bihar, West Bengal, and Jharkhand) are favorable for the cultivation of long duration pigeonpea varieties. The sowing season begins in July first fortnight and the crop gets prolonged vegetative phase for acquiring sufficient biomass. The extreme cold spell months of December and January freezes the crop reproduction. As the day/night temperature raises from the second fortnight of February the crop switch to its full bloom and complete podding by the first fortnight of April. North East Plain Zone contributes about 12.2% of total pigeonpea area and 15.26% of production in the country. Owing to its long duration, pigeonpea cultivation NEPZ is also considered as the high yielding zone (18-25 q/ha) (AICRP on pigeonpea annual report, 2019-20).

Genetic enhancement is a ray of hope for manipulating pigeonpea crop to perform better under limited resources and stressful environment. Positive genetic improvement increases the productivity per unit resources consumed and decreases the gap of demand and supply. Keeping this in view the present varietal development programme was initiated to develop high yielding, wilt and sterility mosaic disease resistance variety in pigeonpea for cultivation in NEPZ.

MATERIAL AND METHODS

The pigeonpea variety 'IPA 15-2' was developed at ICAR-Indian Institute of Pulses Research, Kanpur by crossing NDA 1/MAL 13 parents. The female parent NDA 1 was the selection of Faizabad local landrace. NDA 1is compact with indeterminate growth habit, semi spreading branches suitable for sole cropping; it produces yellow flowers with sparse red streaks on the dorsal side of the standard petal, green pod and tolerant to wilt and SMD. Whereas, the female parent MAL 13 [Pedigree: MA 2/MA 166 // Bahar] is spreading, indeterminate in growth habit, yellow flowers with sparse red streak and green purple streaked pods. MAL 13 is tolerant to wilt, pod borer and sterility mosaic disease (Fig 1).

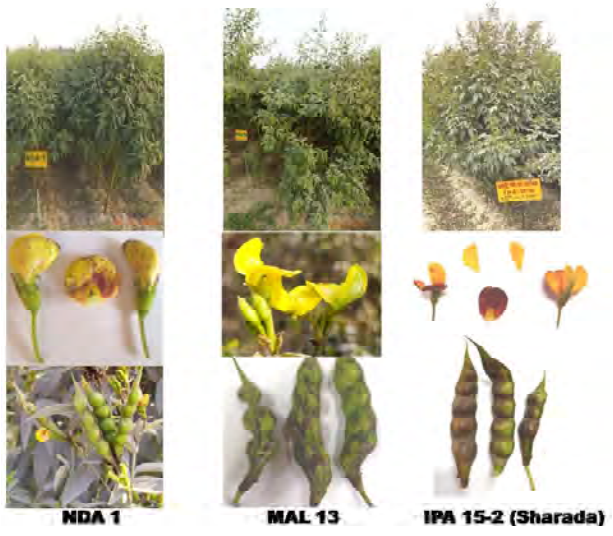

Fig 1. Morphological features of male (NDA 1) and female (MAL 13) parents of IPA 15-2 (Sharada) variety

The new variety IPA 15-2 (Sharada) was developed through pedigree breeding method to track the historical data on line development as given in the Figure 2. From F_2 to F_6 generations the line was maintained through single seed descent method and after F_6 plant to progeny row was adopted for generation advancement. The variety IPA 15-2 was subjected to preliminary yield trial, station trial and disease resistance screening at ICAR-IIPR, Kanpur.

Identified for release in NEPZ by Central Variety Release Committee (CVRC) on 1st October, 2020 and

Pigeonpea Variety 'IPA 15-2 (Sharada)'
↓
Parent 1(NDA 1) × Parent 2(MAL 13)
↓
F_1
↓
2 and 6 in foot materials handled through pedigree methods
↓
Preliminary yield trials (PYT)
↓
Tested in Station trial
↓
Nominated in IVT (Late), AICRP on pigeonpea (2017-18)
↓
Tested for three year under ICAR-AICRP on pigeonpea (2017-18 to 2019-20)
↓
Based on three years AICRP performance showed 23.47% and 24.38% superiority in grain yield over the national check (Bahar) and zonal check (IPA 203) respectively
↓
Identification proposal invited after concluding AICRP on pigeonpea annual group meet (2020)

Fig 2. Flow chart details of development of variety IPA 15-2 (Sharada)

subsequently notified in 85th meeting of the Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops held on 9th November, 2020

The progressive performance of the entry at station level led to further nomination for testing under ICAR-All India Coordinated Research Project (AICRP) on pigeonpea varietal adoptive trials. IPA 15-2 was rigorously screened for yield stability, wilt and Sterility Mosaic Disease (SMD) resistance, pod borer, pod bugs and pod fly tolerance under ICAR-AICRP on pigeonpea varietal adoptive testing trials from 2017-18 to 2019-20. The IPA 15-2 variety has recorded distinct genetic gain over its both the parents (NDA 1 and MAL 13) and National (Bahar) and zonal, IPA 203 (Prakash) check varieties.

Based on its unbeatable performance in AICRP on pigeonpea testing trials, Sharada was identified for release by Central Variety Release Committee (CVRC), on 1st October, 2020 and subsequently notified in 85th meeting of the Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops held on 9th November, 2020 for commercial cultivation under rainfed/irrigated, timely sown conditions of NEPZ comprising Uttar Pradesh, Bihar, Jharkhand and West Bengal states.

DNA profiling of the variety IPA 15-2 (Sharada) was performed using six pigeonpea specific SSR markers (Table 1). Modified Kjeldhal, (1883) technique was used for the estimation of whole grain crude protein content, dry seed samples of IPA 15-2 was taken for protein analysis (Satheesh *et al.*, 2016).

RESULTS AND DISCUSSION

Yield superiority and adaptability

The variety IPA 15-2 (Sharada) was initially tested in preliminary yield trial (PYT)and simultaneously for wilt and sterility mosaic (SMD) disease resistance at sick fields of ICAR-IIPR during 2015-16. Based on the yield superiority over checks and stable resistance reaction to wilt and SMD it was evaluated in 2016-17 station trial (ST) at ICAR-IIPR, Kanpur. The superior performance of IPA 15-2 in PYT and ST led to nomination for Initial Varietal Trial (IVT) under All India Coordinated Research Project (AICRP) on Pigeonpea in 2017-18. The variety IPA 15-2 (Sharada) was tested for three years (2017 to 2019) across seven locations of North East Plain Zone (NEPZ) namely Varanasi, Dholi, IARI Pusa (Bihar), CSAUA & T, Kanpur, Ranchi, Chianki and Arual for yield stability to reveal that the weighted mean grain yield of IPA 15-2 was 2266 kg/ha for the maturity duration of 250-255 days. IPA 15-2 recorded 23.47% yield superiority over the national check Bahar and 24.38% over the recently released zonal check variety IPA 203 (Prakash). Of the total sixteen test locations, IPA 15-2 was superior in performance at ten locations (Table 1).

As inferred from the Table 3, the location wise yield data analysis for the new variety IPA 15-2 (Sharada) showed that the testing centre Varanasi (Uttar Pradesh) recorded the highest grain yield of 2998 kg/ha followed by Chianki (Jharkhand), CSAUA & T, Kanpur (Uttar Pradesh) and Sabour (Bihar) with mean grain yield of 2667, 2577 and 2558 kg/ha, respectively. Stability in yield performance of IPA 15-2 at diverse locations, situated in three different states, namely, Uttar Pradesh, Bihar and Jharkhand indicated the wider adaptability of the variety IPA 15-2 (Sharada). Examination of the detail pedigree lineageof the new variety IPA 15-2 (Sharada) unveiled that it accumulated the alleles from five different genotypes viz., Faizabad landrace, NDA 1, MA 2, MA 166 and Bahar at different levels during the course of its development. Presence of the landrace and most popular variety Bahar as one of the parents may possibly be a reason for wider resilience of the new variety IPA 15-2 over temporal and spatial screenings (Satheesh *et al.*, 2020)

Morphological characteristics

The new variety has compact growth habit with green stem and no pubescence on leaves. Its higher yield is manifested due to high number of primary branches (20-24 numbers) and number of pods per plant (295-354). It grows up to 240-270 cm in height and bears 50% flowering in the range of 150-158 days

Table 1. Details of the primers used in DNA profiling of IPA 15-2 (Sharada)

S. No.	Marker Name	Genomic Location	Forward primer (5'-3')	Reverse primer (5'-3')	Tm (°C)	Product size (bp)	Reference
1.	CcGM 17845	scaffold_LG01	CAATGAATATTGTCTTGAACAAATGA	CCCAACCCGATCAAAATCTA	59.8	210	Bohra *et al.* 2017
2.	CcGM 23176	scaffold_LG11	CACGTGGCATCATCCTTATG	ATGTGTGCATGGTTGCATCT	60.0	267	Bohra *et al.* 2017
3.	CcGM17946	scaffold_LG10	AAAAATGATTTGTGTACGAGTTTT	AAATTCGACTTGCTGAAATCAA	58.9	156	Bohra *et al.* 2017
4.	CcGM19653	scaffold_LG10	GTGATGCTGAGATATTCTTGTCC	CATTTGAGCTATTCACTTCTTTCAA	59.0	235	Bohra *et al.* 2017
5.	CcGM08701	scaffold_LG06	GCATTATTGATTCATCATTTTCG	AAACTATGAGGTGTGATGTGATGA	58.5	227	Bohra *et al.* 2017
6.	CcGM12371	scaffold_LG06	AAGGTTAAAGGTGAATGGGGA	TGGCTTGACATGCAAAGAAT	59.3	298	Bohra *et al.* 2017

Table 2. Weighted mean grain yield, percent superiority and frequency data of IPA 15-2 (Sharada) in Coordinated Varietal Trials (2017-2019)

Particulars	Year of testing	No. of locations	IPA 15-2 (New variety)	Bahar (National Check)	NDA-1 (Zonal Check)	MA 6 (Local check)	IPA 203 (Zonal Check)
Mean yield (kg/ha)	2017 (IVT)	4	2153	2012	1968	1945	0
a) Zonal: NWPZ	2018 (AVT 1)	5	2322	1804	1919	1674	1888
	2019 (AVT 2)	7	2324	1726	1825	2027	1848
	Weighted mean yield (kg/ha)	**16**	**2266**	**1847**	**1904**	**1882**	**1868**
Percentage increase or decrease over the checks & qualifying varieties	2017 (IVT)	4	-	(+)7.03	(+)9.40	(+)10.72	-
	2018 (AVT 1)	5	-	(+)28.73	(+)20.99	(+)38.71	(+)23.00
	2019 (AVT 2)	7	-	(+)34.65	(+)27.34	(+)14.65	(+)25.76
	Weighted mean percent superiority	**16**	**-**	**(+)23.47**	**(+)19.24**	**(+)21.36**	**(+)24.38**
Frequency in the top three group over the years	2017 (IVT)	4	2/4	0/4	0/4	0/4	-
	2018 (AVT 1)	5	3/5	0/5	0/5	0/5	1/5
	2019 (AVT 2)	7	5/7	1/7	0/7	3/7	2/7
	Weighted mean for frequency	**16**	**10/16**	**1/16**	**0/16**	**3/16**	**3/12**

Table 3. Centre and year wise grain yield (kg/ha) of pigeonpea variety IPA 15-2 and checks

Year	Name of the trial	No. of locations	New variety	Check varieties				General mean of location	CV (%)
			IPA 15-2	Bahar	NDA-1	MA 6	IPA 203		
2017	IVT (Late)	Dholi	1923	2135	1619	1737	-	1854	12.17
		IARI Pusa (Bihar)	2255	1768	2124	1887	-	2009	11.01
		CSAUA&T, Kanpur	1877	2451	2398	2009	-	2184	13.00
		Sabour	2558	1693	1732	2146	-	2032	19.98
		Zonal mean	**2153**	**2012**	**1968**	**1945**	**-**	**2020**	4.62
		% increase or decrease	-	**(+)7.03**	**(+)9.40**	**(+)10.72**	**-**	**(+)6.62**	
2018	AVT 1 (Late)	Banda	2313	2096	2231	1840	1948	2086	8.37
		Varanasi	2998	2132	2754	2621	2472	2595	11.14
		IARI Pusa (Bihar)	2260	1758	1642	1761	1858	1856	11.50
		Chianki	2054	1996	1796	1337	1546	1746	15.52
		Ranchi	1984	1036	1172	810	1614	1323	31.88
		Zonal mean	**2322**	**1804**	**1919**	**1674**	**1888**	**1921**	11.32
		% increase or decrease	-	**(+)28.73**	**(+)20.99**	**(+)38.71**	**(+)23.00**	**(+)20.85**	
2019	AVT 2 (Late)	Varanasi	2077	1458	1673	2102	1501	1762	15.71
		Dholi	2358	1948	1734	2010	1911	1992	10.27
		IARI Pusa (Bihar)	2296	1315	1256	1817	2099	1757	23.57
		CSAUA&T, Kanpur	2577	2259	2535	2344	1964	2336	9.42
		Ranchi	1852	1505	1447	1551	1655	1602	8.89
		Chianki	2667	1460	1863	2198	1899	2017	19.87
		Arual	2442	2135	2265	2167	1910	2184	7.95
		Zonal mean	**2324**	**1726**	**1825**	**2027**	**1848**	**1950**	10.81
		% increase or decrease		**(+)34.65**	**(+)27.34**	**(+)14.65**	**(+)25.76**	**(+)19.18**	

and requires 240-255 days to attain the maturity. The base flower colour of 'IPA 15-2' is yellow however the outer layer of the standard petal is red (Fig 3). The 100 seed weight is about 10-12 grams and possesses yellow coty led on and creamy brown colored seed coat with smooth surface (Fig 4). Presences of distinct morphological traits serve as markers for easy identification of the variety in context. Thus, it will help in maintaining its genetic purity and admixture from other varieties during large scale seed production.

Resistance to major diseases and insect pests

Fusarium wilt and sterility mosaic disease are important yield reducing biotic stresses in pigeonpea across the country. *Fusarium* wilt is an important soil borne killer disease, which causes up to 100 percent yield loss at favorable disease development condition. Being soil borne, wilt disease is difficult to manage through agro-chemicals. In this context, the variety 'IPA 15-2' has enhanced level of resistance to wilt (15.11%) compared to the susceptible check variety ICP 2376 wherein 77.24% population died due to wilt (Table 4). The high level of wilt resistance offers more durability and ensure optimum crop stand in field. Thus in turn manifests in higher yield per unit area (Satheesh *et al.,* 2012).

As inferred from the Table 5, the sterility mosaic disease caused by *Emaravirus*, which is transmitted

Fig 3. Field view and varietal description of IPA 15-2

Fig 4. Grain and dal of IPA 15-2

Table 4. Reaction to *Fusarium* wilt diseases (Percent wilt incidence recorded during 2018-19)

Disease name	Location	New Variety IPA 15-2	Resistant check (ICP 8863)	Susceptible check (ICP 2376)
Fusarium wilt	Bangalore	9.00	8.50	97.00
	Gulbarga	13.23	8.05	77.50
	Akola	7.69	7.14	22.34
	Khargone	26.00	-	92.00
	Sehore	21.36	9.95	73.47
	IIPR Kanpur	9.15	-	96.94
	Ranchi	19.31	-	81.43
Average wilt incidence		15.11	8.41	77.24

Table 5. Reaction to sterility mosaic diseases (Percent SMD incidence recorded during 2018-19)

Disease name	Location	New Variety IPA 15-2	Susceptible check-1 (ICP 2376)	Susceptible check-2 (ICP 8863)
Sterility Mosaic Disease	**Badnapur**	7.69	0.00	100.00
	Rahuri	28.59	74.18	100.00
	Dholi	9.20	74.00	62.00
	Ludhiana	16.98	-	2.00
Average SMD incidence		15.62	49.39	66.00

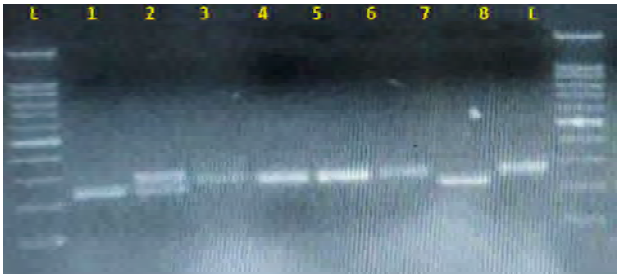

Fig 5. Gel images illustrating DNA profiling of IPA 15-2

L: Ladder 100 bp standard DNA, 1: Pusa151, 2: IPA203, 3: Bahar, 4: NA1, 5: BRG2, 6: IPA206, 7: MA6, 8: IPA15-2

Table 6. Reaction of pigeonpea variety IPA 15-2 (Sharada) to Insect Pests incidence

Parameters	New variety	Check entries				SEm±	CD 5%
	IPA 15-2	Bahar (NC)	IPA 203 (ZC)	NDA 1 (PC-1)	MA 6 (PC-2)	MAL 45 (PC-3)		
Flowering	143	147	141	144	143	150	--	--
Pod damageby *H. armigera*	6	6.73	7.25	4.44	6.25	8.97	0.92	2.76
Pod damageby *M. obtusa*	28.31	43.56	36.44	18.25	22.38	38.25	1.76	5.28
Total pod damage (%)	34.31	50.29	43.69	22.69	28.63	47.22	--	--
Pod damage by Pod fly (%)	51.00 (45.55)	36.00 (36.84)	31.67 (34.19)	47.33 (43.44)	33.67 (35.44)	37.00 (37.44)	1.954	5.85
Grain damage by Pod fly (%)	29.21 (32.65)	13.92 (21.86)	15.33 (22.94)	23.46 (28.90)	21.31 (27.48)	21.30 (27.45)	1.349	4.04
PRR	4	6	6	3	4	--	--	--

through *Eriophyid* mite (*Aceria cajani* Channabasavanna) is another major reproductive constraint in pigeonpea. The new variety IPA 15-2 has only 15.62% mortality as compared to susceptible check ICP 8863, which recorded 66.00% mortality.

The long duration pigeonpea varieties need to with stand in the field for about 240-260 days. Therefore, they get exposed to various kinds' of insect pests. In this regard the new variety has recorded 6% pod damage by *H. armigera* and 28.31% damage by *Maruca obtuse* whereas, the Bahar (National check) recorded 6.73% and 43.56% pod borer damage, IPA 203 (Zonal check) reported 7.25% and 36.44% pod borer damage and MA 6 (Local check) reported 6.25% and 22.38% pod damage by *H. armigera* and *M. obtuse*, respectively (Table 6).

DNA fingerprinting

Six pigeonpea specific polymorphic SSR markers (Table 7) were used for DNA fingerprinting of the new variety IPA 15-2 (Sharada) to distinguish it from other varieties and parents. An amplicons of 280bp for the SSR marker CcGM 23176 was specific to the variety IPA 15-2 as given in the figure 5. Along with the distinct morphological features, the SSR marker based differentiation would certainly be additional advantage to distinguish IPA 15-2 from other varieties during the course of seed production and maintenance of genetic purity.

CONCLUSION

Pigeonpea variety 'IPA 15-2 (Sharada)' is widely adopted in North East Plain Zone comprising the states of Uttar Pradesh, Bihar, Jharkhand and West Bengal. Under rainfed condition, it has recorded 2998 kg/ha grain yield. Cultivation of 'IPA 15-2' pigeonpea variety would provide enhanced level of resistance against wilt and sterility mosaic diseases and thereby assured optimum crop stand and economic yield under well managed field. IPA 15-2 has 19% crude grain protein content. Therefore, being superior in several aspects, the new variety IPA 15-2 would be popular among the farmers, millers and consumers.

REFERENCES

FAOSTAT. 2019. Food and agriculture organization of the united nations, Rome.

Food and Agricultural Organization. 2018. Land and water resource planning. http://www.fao.org/land-water/overview/en/

Ministry of Agriculture and Farmers Welfare, Department of Agriculture, Cooperation and Farmers Welfare, Directorate of Economics and Statistics, First Advance Estimates of Production of Foodgrains for 2020-21. http://agricoop.gov.in

Ministry of Agriculture and Farmers Welfare. Department of Agriculture, Cooperation and Farmers Welfare, Crops Division. Krishi Bhavan. Pulses Revolution from Food to Nutritional Security. https://farmer.gov.in/Sucess Report 2018-19.pdf

Kjeldahl J. 1883. New method for the determination of nitrogen in organic substances. Fresenius' Zeitschrift für Analytische Chemie. **22** (1): 366-383.

Satheesh Naik SJ, Singh IP, Abhishek Bohra, F. Singh, D Datta, RK. Mishra, Shefali Tyagi, Alok Kumar Maurya and NP Singh. 2020. Analyzing the genetic relatedness of pigeonpea varieties released over last 58 years in India. Indian J. Genet., 80(1) 70-76 DOI: 10.31742/IJGPB.80.1.9

Satheesh Naik SJ, Farindra Singh, Raj Kumar Mishra, Abhishek Bohra, IP Singh, SK Chaturvedi, Jagdish Singh and NP Singh. 2016. Characterization of genotypes for wilt, quality and agronomic traits in vegetable pigeonpea [*Cajanus cajan* (L.) Millsp.]. J. Food Legume, **29**(3&4): 216-219.

Satheesh Naik SJ, M Byregowda and SC Venkatesh. 2012. Molecular diversity among pigeonpea genotypes in response to SMD. J. Food Legume. **25**(3): 194-200.