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Research Article

PERFORMANCE OF FARMERS' PIGEON PEA [*Cajanus cajan* L. MILLSP.] VARIETIES: OPPORTUNITIES FOR SUSTAINED PRODUCTIVITY AND DISSEMINATION OF VARIETIES

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Abstract- The Pigeon pea, an excellent source of protein and well balanced nutritionally has very low productivity as compared to its potential yield despite several government efforts for productivity enhancement. Many grassroots innovative farmers have also developed improved varieties of pigeon pea. With the objective to channelize successful farmers' pigeon pea varieties, an *ex situ* evaluation trial comprising of three farmers' developed varieties and two locally popular varieties was conducted during *Kharif* 2014 and 2015 in Gandhinagar, Gujarat. Results revealed significant superiority and suitability of farmers' varieties over local varieties for the area during both the years. Kudrat 3 variety [3253.7 kg/ha] outperformed the other varieties in yield and majority of yield attributing traits followed by Richa 2000 [3075.6 kg/ha]. Strong positive correlation coefficients between yield and yield attributing traits show that these traits have strong impact on yield of the farmers' varieties tested. Superior performances of the varieties also depict their adaptability to the local conditions.More productive results can be obtained by promoting location specific farmers' plant varieties. From the exertion it was established that these farmers' varieties can be considered for channelization and dissemination in similar agro-climatic zones.

Keywords- Grassroots Innovators, Farmers' variety, Pigeon pea, *ex-situ,* Adoption

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Introduction

Pulses are of greatest importance in human diet. India is the major pulse producer, importer and consumer country of the world. In 2013, the total area and production of pulses in world was 81.0 million hectares and 73.21 million tonnes respectively. India contributed 34.77 percent [28. 17 million hectares] and ranks first in the harvested area of total pulses followed by Niger [6 percent] and Nigeria [4.80 percent] in the world and ranks first in pulses production accounting about 25.01 percent [18.31 million tonnes] of the total production worldwide [6]. The world's total yield was about 9038 hectogram per hectare and India was at 176th position with 6500 hectogram per hectare [3]. Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, Karnataka, Andhra Pradesh, Chhattisgarh, Tamil Nadu, Odisha and Jharkhand are the ten major pulses growing states and account for 90 percent of total pulse production and area. The total consumption of pulses in India was 21.74 million tonnes of which 4.58 million tonnes were imported and total production was 17.19 million tonnes during 2014-15 [7].

Pigeon pea is second most important pulse crop of India after chickpea which is well balanced nutritionally. It is a multipurpose crop providing food, fodder, feed, fuel, functional utility, forest use and fertilizer in context of sustainable agriculture [5]. It is an excellent source of protein [21.7g /100g], dietary fibres [15.5g /100g], soluble vitamins, minerals and essential amino acids [18, 5]. Pigeon pea is also used in traditional medicines and leaves, flowers, roots, seeds are used for the cure of bronchitis, sores, respiratory ailments and also acts as an alexeritic, anthelmintic, expectorant, sedative, and vulnerary [15]. India is one of the major pigeon pea producing countries with 63.74 percent of total global production followed by Myanmar [18.98 percent], Malawi [6.07 percent], Tanzania [4.42 percent] and Uganda [1.98 percent] [5]. The total area under pigeon pea cultivation during 2014-15 was ~3.9 million hectares producing around 2.81 million tonnes of pigeon pea with an average national productivity of 729 kg/ha [7]. It is drought tolerant legume grown mainly in the semi-arid tropics though it is adapted to several environments [20, 4]. Pigeon pea is often cross pollinated crop. It is very difficult to maintain genetic purity of seed at farm level. Therefore, well-organised seed production plan in each agro-climatic zones by involving farmers and other stakeholders is necessary for multiplication and supply of seeds of improved and high yielding varieties to farmers. It was observed that in recent past a number of improved varieties of pulses have been released for cultivation. But in 2010-11, the seed replacement rates [SRR] of pulses and pigeon pea were only 22.51 percent and 21.23 percent respectively [16]. The farmers still use traditional/their own saved and developed varieties of seeds. High yields, resistance to pest attack, synchronous maturity time and other characteristics such as cooking quality, taste and storability are key criteria used by farmers in making a choice of any crop including pigeon pea [13]. Pigeon pea is mainly cultivated in Maharashtra, Karnataka, Madhya Pradesh, Andhra Pradesh, Uttar Pradesh, Gujarat, Jharkhand, Odisha and Tamil Nadu. About 98 percent of total cultivation area of pigeon pea is occupied by these ten states in India [7].

Despite many government, private & NGO's projects continuously working for yield and quality improvement of pulse crops, the productivity [729 kg/ha] of pigeon pea of Indian varieties is still very low as compared to its potential yield of 25-30 quintal per hectare [7, 5] due to inaccessibility of improved and high yielding varieties, several biotic and abiotic factors, unfavourable rainfall, lack of knowledge about recommended package of practices and low adoption of recommended technologies by the farmers [14, 5]. The price trend of pigeon pea is increasing day by day which indicates that the supply of pigeon pea is not able

to meet the increase in demand due to supply side constraints such as biotic, abiotic stress and other socio-economic constraints. Another important reason for non-preference of pulses by farmers is continued higher instability in yields of pulse crops than major cereal crops [2]. Hence, farmers are still using local unimproved varieties, technologies and practices. Therefore, there is a requirement to explore, document scientifically and collect the pigeon pea genotypes from farmers of the country. Many of grassroots innovators who have developed plant varieties reported that the varieties show superior performance in terms of high production, pest and drought tolerance, shattering resistance and show better adaptation in various environmental conditions. Most of the farmers' varieties were developed by using selection method based on its performance in the field. The objective of this study is to evaluate the performance, channelize successful farmers' varieties and select the superior ones for further study. The farmers' and traditionally cultivated varieties of pigeon pea can help plant breeders in providing an important source of genetic material for crop improvement programmes and developing improved varieties [11].

Materials and Methods

The field experiments for the performance evaluation of pigeon pea varieties received from two grassroots innovators of different states were conducted at NIF's research farm, Gandhinagar during two consecutive years in *Kharif* 2014 and 2015. The experiment site is located at 23.37°N latitude, 72.71°E longitude and at an altitude of 103 meter above mean sea level. The soil of experimental site was loamy sand in texture. The treatments comprised of five varieties i.e. Kudrat 3 developed by Shri Prakash Singh Raghuvanshi from Uttar Pradesh, Richa 2000 and Richa 2001 developed by Shri Rajkumar Rathore of Madhya Pradesh, Chotila and local from Gujarat which were replicated in four blocks under randomized block design in 8.1 x 5.4 meter^2 plot size with the spacing of 90 x 90 cm inter-row and intra-row. Standard recommended agronomic practices were adopted to stand a good crop. The data were recorded for fifteen quantitative and qualitative yield attributing characters *viz.* plant height [cm], number of primary and secondary branches per plant, number of pods per plant, number of seeds per pod, pod length [cm], seed yield [g/plant], seed yield [kg/plot], total seed yield [kg/hectare], 100-seed weight [g], maturity period, days to 50 percent flowering and colour of flower, pod and seeds from five randomly selected plants in each plot. All the data collected was subjected to ANOVA to find out significant difference among the parameters studied. Correlation coefficients were also calculated to find out the impact of yield attributing traits on the performance of the varieties under study. All the calculations were done using Graphpad Prism 5 software and Ms Excel.

Results and Discussions

Analysis of variance revealed significant difference among the different farmers' varieties for all the characters studied indicating existence of ample variations in the varieties under study. These variations are probably due to their different origins, impact of environment and different agro-climatic zones from where they have originated.

The plant height differed significantly among the varieties tested, in both the years. Kudrat 3 variety outperformed the rest with an average height of 2.56 meter followed by Richa 2001 and Richa 2000, which is significantly superior over both local checks and found at par with all other varieties [Table-1, 3]. All the varieties under study were tall and this could be attributed to the fact that plant height in pigeon pea is influenced by maturity duration, photoperiod and environment [15]. Similar significant variations in genotypes for different yield attributing traits have also been reported in the previous studies of Manivel *et al.,* [12] and Kumara *et al.,* [9]. The plant height recorded high positive correlation with grain yield /plot [r= 0.929], grain yield/plant [r=0.917], total grain yield/hectare [r=0.917] and seeds/pod [r = 0.860] at p ≤ 0.01 [Table-2]. Positive correlation was also observed with the traits number of pods/plant, pod length, test weight, maturity period and days to 50 percent flowering showing positive impact of plant height on these traits and vice versa as observed by Kundy *et al.*, [15]. Only the trait secondary branches had very low positive correlation with plant height [Table-2].

Table-1 *Performance evaluation of three farmers' developed varieties in comparison with two local varieties combine over two years.*

Treatment	Plant Height	Primary Branches	Secondary Branches	Pods per plant	Seeds per pod	Pod length [cm]	Grain yield per plant [g]	Grain yield/ plot [kg]	Yield /ha [kg]	100 grains weight [g]	Days to 50% flowering	Maturity period [days]
T1 [K3]	2.56*	21.68*	80.53^{NS}	456.98	4.36*	9.00*	263.55*	14.11*	3253.70*	17.25*	145.63*	232.88
T2 [R2k]	2.39	12.80	29.95	738.03	3.71	8.48	249.13	13.00	3075.62	13.50	121.75	205.25
T3 [R2k1]	2.50	17.25	54.53	939.63*	3.61	6.82	212.10	11.45	2618.52	12.38	126.00	235.38*
T4 [Ch]	1.88	14.73	57.03	451.15	3.17	6.55	143.55	7.75	1772.22	12.13	106.13	206.50
T5 [L]	2.01	16.88	64.70	435.23	3.23	6.46	137.05	7.40	1691.98	12.63	130.88	197.38
SEm±	**0.09**	**1.58**	**15.19**	**77.76**	**0.20**	**0.25**	**14.69**	**0.82**	**181.37**	**0.68**	**1.45**	**1.48**
CD 5%	**0.29**	**4.87**	**NS**	**239.61**	**0.63**	**0.76**	**45.27**	**2.51**	**558.85**	**2.09**		
CV %	**8.36**	**18.90**	**51.87**	**25.05**	**11.36**	**6.61**	**14.50**	**15.08**	**14.50**	**9.99**		

*Significant at 0.05; NS- non significant [Analysis of variance]

Table-2 *Correlation coefficients between yield attributing characters of three farmers' developed varieties and two local varieties combined over two years.*

Parameter	Plant Height	Primary Branches	Secondary Branches	Pods per plant	Seeds per pod	Pod length [cm]	Grain yield/ plant [g]	Grain yield /plot [kg]	Yield/ha [kg]	100 grains weight [g]	Maturity period [days]	50% flowering [days]
Plant Height												
Primary Branches	0.450											
Secondary Branches	0.045	0.911										
Pods per plant	0.560	-0.266	-0.555									
Seeds per pod	0.860	0.653	0.342	0.080								
Pod length [cm]	0.716	0.313	0.029	0.003	0.898							
Grain yield/plant [g]	0.917	0.297	-0.082	0.388	0.906	0.914						
Grain yield/plot [kg]	0.929	0.337	-0.042	0.388	0.919	0.905	0.999					
yield per ha [kg]	0.917	0.297	-0.082	0.388	0.906	0.914	1.000	0.999				
100 grains weight [g]	0.617	0.732	0.541	-0.299	0.927	0.855	0.718	0.731	0.718			
Maturity period[days]	0.783	0.656	0.389	0.456	0.688	0.361	0.610	0.646	0.610	0.482		
50% flowering [days]	0.668	0.810	0.583	-0.096	0.774	0.574	0.551	0.571	0.551	0.796	0.476	

Maximum numbers of primary and secondary branches were recorded in Kudrat 3 which was higher than other varieties and local checks but, the number of pods per plant was significantly higher in Richa 2001 followed by Richa 2000 and Kudrat 3 and local checks in both the years [Table-1, 3]. A low negative correlation was observed between pods per plant and primary and secondary branches indicating an inverse relation between the two [Table-2]. This may be

attributed to the fact that the vegetative and reproductive growth of the plants are very taxing on plants and over expression of one trait may hamper the growth of the other as manifested in the present study. Some of these results [plant height with positive correlation with number of primary branches, secondary branches] are antagonistic to the previous results of Sreelakshmi *et al.,* [19] where apical dominance was the reason of increased plant height. In the present study, it seems that the apical dominance does not hamper the growth of primary and secondary branches.

Table-3 *Analysis of variance of different yield attributing traits of two farmers' developed pigeon pea varieties in comparison with local varieties combined over two years.*

Traits	Source of variation	df	SS	MS	F calc	F tab	P-value summary
Ph	Replication	3	0.06	0.02	0.66	3.49	NS
	Treatment	4	0.69	0.17	5.59	3.26	S
	Error	12	0.37	0.03			
	Total	19	1.12				
Pr Br	Replication	3	50.96	16.99	1.31	3.49	NS
	Treatment	4	222.30	55.58	4.29	3.26	S
	Error	12	155.54	12.96			
	Total	19	428.80				
Sc Br	Replication	3	3558.95	1186.32	0.61	3.49	NS
	Treatment	4	-15800.20	-3950.05	-2.04	3.26	NS
	Error	12	23211.80	1934.32			
	Total	19	10970.55				
Po/Pl	Replication	3	79168.15	26389.38	0.60	3.49	NS
	Treatment	4	819524.80	204881.20	4.66	3.26	S
	Error	12	528067.60	44005.63			
	Total	19	1426760.55				
Se/Po	Replication	3	1.00	0.33	1.43	3.49	NS
	Treatment	4	3.42	0.85	3.66	3.26	S
	Error	12	2.80	0.23			
	Total	19	7.22				
PoL	Replication	3	1.11	0.37	0.82	3.49	NS
	Treatment	4	23.99	6.00	13.23	3.26	S
	Error	12	5.44	0.45			
	Total	19	30.55				
Gy/Pl	Replication	3	3964.73	1321.58	0.93	3.49	NS
	Treatment	4	54599.02	13649.76	9.59	3.26	S
	Error	12	17081.75	1423.48			
	Total	19	75645.50				
GY/Pt	Replication	3	2.69	0.90	0.20	3.49	NS
	Treatment	4	135.86	33.96	7.52	3.26	S
	Error	12	54.16	4.51			
	Total	19	192.70				
Y/ha	Replication	3	604287.76	201429.25	0.93	3.49	NS
	Treatment	4	8321752.78	2080438.19	9.59	3.26	S
	Error	12	2603528.12	216960.68			
	Total	19	11529568.66				
100GW	Replication	3	2.20	0.73	0.39	3.49	NS
	Treatment	4	55.30	13.83	7.44	3.26	S
	Error	12	22.30	1.86			
	Total	19	79.80				
MP	Replication	3	30.15	10.05	1.22	3.49	NS
	Treatment	4	5397.70	1349.42	163.40	3.26	S
	Error	12	99.10	8.26			
	Total	19	5526.95				
50% Fl	Replication	3	60.55	20.18	2.19	3.49	NS
	Treatment	4	3579.70	894.93	97.01	3.26	S
	Error	12	110.70	9.23			
	Total	19	3750.95				

S= significant at 5%, NS = non significant

Abbreviations: Ph**-** Plant Height; Pr Br- Primary Branches; Sc Br- Secondary Branches; Po/Pl- Pods per plant; Se/Po- Seeds per pod; PoL- Pod length; Gy/Pl Grain yield/plant; Gy/Pt- Grain yield/plot; Y/ha - yield per ha; 100GW- 100 grains weight; MP-Maturity period, 50%Fl - 50% flowering; df- degree of freedom; SS- sum of squares; MS – mean sum of squares;

All the tested varieties fall under the medium [106.13 days in Chotila variety] to late [145.63 days in Kudrat 3] category of DUS guidelines for pigeon pea of PPV&FRA [1] in terms of days required for 50 percent flowering, whereas significant maximum maturity period was recorded in Richa 2001 with an average of 235.38 days which is 38 days more than the local check [T5] [Table-1, 3]. Kudrat 3 recorded maximum pod length and seeds per pod which was significantly higher than other test varieties [Table-1, 3]. The number of pods per plant was significantly highest in Richa 2001 variety but the other yield attributing traits like grain yield per plant, grain yield per plot, 100 grains weight and total yield per hectare was recorded highest in Kudrat 3, significantly higher than the other varieties tested [Table-1, 3]. A low negative correlation was also observed between the number of pods per plant and 100 grain seed weight [Table-2]. This may be attributed to the fact that seed weight vary due to uneven maturity, poor pod filling and small sized seeds in pigeon pea [19]. At a time a large number of pods may be present on a plant but they all may not mature synchronously, producing seeds of different grades and thus reducing the overall test weight. Similar results were observed by Khake *et al.,* [8]. A perfect positive correlation [r = 1.0] was observed between grain yield per plant and total yield per hectare while highly significant correlations were observed between the yield and plant height, seeds per pod, pod length and grain yield per plot showing the direct positive

influence of these yield attributing traits on the yield in both the years [Table-2]. Results congruent with the current study were also reported by Singh and Singh [17]. The average 50 percent germination period ranged between 8 – 12 days, shortest being in Kudrat 3. Kudrat 3 variety had yellowish red flowers with green pods and brown seeds, Richa 2000 had red flowers, green pods with brown streaks and dark brown seeds and Richa 2001 had red and yellow flowers, purple pods and black seeds. The control varieties bore yellow flowers, dark purple pods and cream coloured seeds showing variations in morphological characters too.

Conclusions

The variety Kudrat 3 performed significantly superior than Richa 2000 and Richa 2001 in majority of yield attributing traits tested in both the years of study producing highest yields in both the consecutive years. It was a bold seeded variety and performed well under the test area showing its adaptability to new agro-climatic zones. Similar trends were also observed in case of Richa 2000 and Richa 2001 in both the years. To overcome the shortages of pulses in the country, Farmers' varieties such as Kudrat 3 , Richa 2000 and Richa 2001 play a crucial role, not only in terms of production but also provide suitable germplasm for further development and release of new varieties by the formal scientific community. The varieties like these easily adapt to local environmental conditions without any significant changes in production, hence emphasizing the need for promotion of such locally suited varieties for self-sustenance in pulse production.

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Ethical Approvals

The experiments were performed as per the guidelines of NIF-India. This article does not contain any studies with human participants or animals performed by any of the authors.

Conflict of interest: The authors have no conflict of interest.

Author Contributions

Shri Prakash Singh Raghuvanshi and Shri Rajkumar Rathore have developed the varieties of pigeon pea. Shri Hardev Choudhary and Dr. Noushad Parvez initiated and conducted the field trials. Dr. Satya Singh analysed the data and with inputs from Shri Hardev Choudhary prepared the manuscript.

Abbreviations

ANOVA= Analysis of Variance
Ch = Chotila variety
cm = centimetre
g = grams
ha= hectare
K3= Kudrat 3 variety
kg= kilograms
L= Local variety conserved by farmer
NS= non-significant
R2k = Richa 2000 variety
R2k1= Richa 2001 variety
S= significant

Conflict of Interest: None declared

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