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Impact of enhanced farming techniques on pigeon pea yield and economic viability in the Vindhya plateau Agro-climatic zone, Sagar district, Madhya Pradesh

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Abstract
Within the realm of pulse crops, pigeon pea (*Cajanus cajan* (L.) Millsp.) emerges as a pivotal crop for India, contributing to a staggering 91% of the global pigeon pea production. However, the productivity of pigeon pea cultivation in Madhya Pradesh, particularly in the Sagar district, falls significantly below its inherent production potential. Notably, inadequate crop management and protection technologies stand out as the predominant factors contributing to the observed suboptimal yield of pigeon pea. To rectify this anomaly, the Krishi Vigyan Kendra in Sagar, Madhya Pradesh, orchestrated a comprehensive intervention in the form of 195 cluster frontline demonstrations (CFLD) across an expansive 80-hectare domain. This initiative featured the cultivation of the short-duration pigeon pea variety TJT 501, coupled with enhanced packages and practices, implemented on farmers' fields during the period spanning 2016 to 2019. The culmination of three years under CFLDs showcased compelling results for pigeon pea cultivation. The average grain yield under demonstration plots soared to 9.21 quintals/ha, a substantial improvement compared to the meagre 5.76 quintals/ha recorded in traditional farming practices. This translated to an average yield advantage of a remarkable 63.28% over conventional farming methods. The pinnacle of achievement was observed in the 2018-19 season, wherein the highest grain yield of 9.83 quintals/ha was documented, representing a notable 60.36% increase over traditional practices (6.13 quintals/ha). Conversely, the nadir was registered under Farmers' Lead Demonstrations (FLDs) plots at 8.27 quintals/ha and 4.40 quintals/ha in traditional farming during the 2017-18 season. Moreover, the financial implications of this intervention were profound, with an average net profitability of Rs. 24,991 per hectare, significantly surpassing the Rs. 12,265 per hectare derived from conventional farming practices. The benefit-cost ratio mirrored this success, standing at 2.59 in the demonstrated plots and 1.89 in traditional farming practices. An analysis of the technology gap in pigeon pea cultivation under CFLDs revealed a range of 8.17 to 9.73 quintals/ha, while the extension gap varied from 2.80 to 3.87 quintals/ha. The technology index exhibited variability, ranging from 47.00 to 54.06%. These fluctuations can be attributed to diverse agro-climatic parameters, soil fertility, biotic stresses, socio-economic factors, and management practices. Mitigating these variations necessitates a concerted effort to encourage farmers to adopt economically viable technologies, thereby enhancing the production and productivity of pigeon pea crops.

Keywords: Cluster frontline demonstrations, pigeon pea, technology and extension gap, BCR

Introduction
Pulses, as a primary protein source (constituting 20-25% of protein intake), form an essential part of the dietary spectrum in India, cultivated across diverse agro-climatic conditions. Rich in dietary fiber, vitamins, and essential minerals such as iron, magnesium, phosphorus, zinc, selenium, and potassium, pulses play a pivotal role in human health. Beyond their nutritional impact, pulses contribute significantly to climate change mitigation through nitrogen fixation, involvement in crop rotation, mixed and inter-cropping, and the maintenance of soil fertility, thereby bolstering the sustainability of farming systems and exerting positive environmental effects. In India, the predominant pulses, including pigeon pea, urd bean, mung bean, cowpea, chickpea, lentil, and peas, are cultivated in two distinct seasons – kharif (June-October) and Rabi (October-April). Pigeon pea (*Cajanus cajan* (L.) Millspaugh), a cross-pollinated crop with a diploid chromosome number of 2n=2x=22 and a genome size of 833.1 mega base pairs, belongs to the Leguminosae family.

Globally, pigeon pea cultivation spans 6.35 million hectares, yielding 5.47 million tons with an average productivity of 861.60 kg/ha (FAOSTAT, 2021) [5]. In India, it holds the second position among pulse crops, being the largest producer and consumer of pulses worldwide. In the 2021-22 period, India cultivated pigeon pea across 5.05 million hectares, producing 4.34 million tons, with a productivity of 859.00 kg/ha (Agricultural Statistics at a Glance, 2022) [1]. In the state of Madhya Pradesh, pigeon pea is cultivated over 0.37 million hectares, yielding 0.35 million tons annually, with a productivity of 936 kg/ha (Agricultural Statistics at a Glance, 2022) [1]. In the Sagar district during 2020-21, 2650 tons were produced from 2524 hectares, achieving an average productivity of 10.05 quintals/ha (DES, 2022) [2]. The lower productivity of pigeon pea can be attributed to various factors, including the unavailability of high-yielding varieties, improper sowing practices, higher seed rates, inadequate and imbalanced use of fertilizers, suboptimal weed management, and the non-adoption of appropriate plant protection measures. Addressing these challenges necessitates creating awareness among the farming community to popularize location-specific improved varieties, thereby increasing pigeon pea production and productivity in the district. To this end, an extensive intervention, in the form of cluster frontline demonstrations, was conducted from 2016-17 to 2018-19, introducing and disseminating improved pigeon pea varieties (TJT 501) along with technological interventions to enhance crop yield. This manuscript focuses on the outcomes of these interventions, detailing the yield enhancement of improved pulse crop varieties, examining yield gaps, assessing technology adoption, and evaluating the horizontal spread of these advancements at farmers' fields.

Materials and Methods

Sagar, situated within the Vindhya Plateau Agro-Climatic Zone of Madhya Pradesh, holds considerable agricultural significance. The Krishi Vigyan Kendra Sagar undertook a series of cluster frontline demonstrations (CFLDs) as part of the National Food Security Mission scheme during the kharif seasons spanning from 2016-17 to 2018-19. Specifically, 195 CFLDs were implemented, focusing on pigeon pea across an expansive 80-hectare area. Prior to commencing these demonstrations, an extensive survey was conducted to pinpoint farmers with specific needs. The selection of receptive and innovative farmers occurred through group meetings, taking into account factors such as accessibility and adaptive attitudes. The chosen farmers underwent targeted skill training in various agro-techniques designed to enhance pulse crop productivity.

Each CFLD covered an acre, with traditional practices serving as the control. Field days were meticulously organized at the crop maturity stage in each cluster, showcasing the demonstration results to farmers within the same village and neighboring areas, thereby facilitating horizontal technology spread. The demonstrations incorporated essential inputs, including the improved pigeon pea variety TJT 501, and adhered to a comprehensive package of practices covering proper tillage, seed rate, sowing time and method, balanced fertilizer application (18 kg Nitrogen, 46 kg P2O5/ha), Trichoderma seed treatment (5 gm/kg of seed), Rhizobium culture seed treatment (200 gm/10 kg of seed), appropriate irrigation, weed management, and enhanced plant protection measures (refer to Table 1). The supervision of the demonstration plots was carried out by KVK scientists.

Data on yield and cost details were meticulously collected separately by KVK scientists from both CFLDs and farmers' practices. Information on technology adoption and horizontal spread was acquired through interviews with farmers. The cost of cultivation, net return, and benefit-cost ratio were computed utilizing the average prices of input and output commodities prevailing during each demonstration year. Yield parameters from both demonstrations and checks involving farmers' practices were recorded. The technology gap, extension gap, and technology index were determined following the methodologies advocated by Samui *et al.* (2000) [11] and Dayanand *et al.* (2012) [15].

$$\text{(A) Impact on yield (\%)} = \frac{\text{Dy - Fpy}}{\text{Fpy}} \text{x100}$$

Where,
Dy= Demonstrated yield
Fpy=Farmer practice yield

(B) Extension gap= Dy - Fpy

(C) Technology gap= Potential Yield (Py) - Demonstrated Yield (Dy)

$$\text{(D) Technology index (\%)} = \frac{\text{Py - Dy}}{\text{Py}} \text{x100}$$

$$\text{(E) Benefit cost ratio (BCR)} = \frac{\text{Gross return (Rs/ha)}}{\text{Gross expenditure (Rs/ha)}}$$

However, data about adoption and horizontal spread of technologies were collected from the farmers with the help interview schedule. Data were subjected to suitable statistical methods. The following formulae were used to assess the impact on different parameters of pulse crops.

$$\text{Impact on Yield (\% Change)} = \frac{YD_p - YC_p}{YC_p} \times 100$$

Where,
YD_p= Yield of demonstrated plot
YC_p= Yield of control plot

$$\text{Impact on Adoption (\% Change)} = \frac{A_{ad} - A_{bd}}{A_{bd}} \times 100$$

Where,
A_{ad} =No. of Adopters after demonstration
A_{bd}=No. of Adopters before demonstration

$$\text{Impact on Horizontal spread (\% change)} = \frac{A_{iad}\text{ (ha)} - A_{bd}\text{ (ha)}}{A_{bd}\text{ (ha)}} \times 100$$

Where,
A_{iad}= Area increased after demonstration
A_{bd}= Area before demonstration

Results and Discussion

Impact of cluster frontline demonstrations (CFLDs) on pigeon pea crop yield: This investigation delves into the repercussions of cluster frontline demonstrations (CFLDs) on enhancing the yield of diverse pulse crops. Table 1 outlines the findings, illustrating that the average yield in plots featuring demonstrated pigeon pea reached 9.21 quintals/ha, surpassing the 5.76 quintals/ha in control plots. This marks a substantial and positive escalation of 63.28 percent in the average yield of pigeon pea demonstration plots compared to the conventional practices of farmers. Over the demonstration period, the percentage surge in pigeon pea yield fluctuated between 41.54 and 87.95, underscoring the advantageous impact of frontline demonstrations on pulse crop yield within the demonstrated area. Similar observations regarding yield augmentation in frontline demonstrations of pulse crops have been recorded by Dwivedi *et al.* (2013) [4], Singh *et al.* (2021) [14], and Singh *et al.* (2022) [12].

Technology gap: The disparity between the potential yield and the yield in demonstration plots for pigeon pea ranged from 8.17 to 9.73 quintals/ha during the demonstration period (refer to Table 1). The average technology gap identified over the three-year CFLDs in pigeon pea crops was 8.79 quintals/ha. This indicates an existing gap in technology demonstration, hindering participating farmers from realizing the potential yield achievable through improved practices. Possible factors contributing to this gap encompass variations in soil fertility, individual farmers' managerial skills, and climatic conditions in the area. Thus, location-specific recommendations become imperative to address these disparities. These findings resonate with those reported by Vijaya Lakshmi *et al.* (2017) [16], Singh *et al.* (2021) [14], and Singh *et al.* (2022) [12].

Extension gap analysis

Throughout the demonstration period for pigeon pea crops, extension gaps varied between 2.80 and 3.87 (refer to Table 1). This study pinpointed the average extension gap under a three-year CFLD (Cluster Frontline Demonstrations) in the pigeon pea crop program as 3.46 quintals/ha. It is crucial to bridge this gap through diverse extension methods, underscoring the necessity to educate farmers using various techniques to facilitate the adoption of improved agricultural production technologies. The goal is to mitigate the widening extension gap and advocate for the use of cutting-edge production technologies, in tandem with high-yielding varieties, to counteract this disconcerting trend. This discovery aligns with previous studies conducted by Joshi *et al.* (2014) [6], Kumar *et al.* (2014) [8], Kulkarni *et al.* (2018) [7], Singh *et al.* (2021) [14], and Singh *et al.* (2022) [12].

Assessment of technological feasibility

The technology index serves as an essential gauge of the viability of the demonstrated technology in the context of pigeon pea crops. In our study, the technology index for pigeon pea ranged from 47.00 to 54.06 percent, as illustrated in Table 1. Over the three years of Cluster Frontline Demonstration (CFLD) implementation, an average technology index of 50.02 percent was observed, indicating the effectiveness of the applied technical interventions. This suggests the potential for widespread adoption of these demonstrated technological interventions to enhance the yield performance of pulse crops. It is important to note that the variability in the technology index underscores potential variations in outcomes due to factors such as soil fertility, weather conditions, and crop management practices. The reduction of the technology gap and subsequent decrease in the technology index can be achieved through the adoption of improved practices. Comparable observations have been reported by Joshi *et al.* (2014) [6], Kumar *et al.* (2014) [8], Singh *et al.* (2021) [14], and Singh *et al.* (2022) [12].

Economic impact of cluster frontline demonstrations (CFLDs) on pulse crop production

Our study delved into the economic implications of pigeon pea crop production within the framework of Cluster Frontline Demonstrations, with detailed findings presented in Table 2. Technological interventions, including the utilization of high-yielding variety seeds, fertilizers, bio-fungicides, bio-insecticides, and chemical pesticides, were considered in the economic assessment. Pigeon pea cultivation under these demonstrated practices showed a maximum average gross monetary return of Rs. 41860.67/ha, surpassing the Rs. 26182.00/ha from traditional farming practices by 62.85 percent. The average net returns for demonstrated pigeon pea crops were Rs. 24991.00/ha, compared to Rs. 12265.33/ha from farmers' practices. This reflects a significant overall increase of 107.66 percent in average net returns from the demonstrated plots, underscoring the economic advantages of improved technologies. The higher gross monetary return obtained by farmers highlights the economic feasibility of the introduced technology. The average benefit-cost ratio for demonstration plots of pigeon pea was 2.59, in contrast to 1.89 for farmers' practices. Comparable findings have been reported in frontline demonstrations on pulse crops by Lathwal (2010) [9], Dwivedi *et al.* (2014) [3], Singh *et al.* (2020) [13], Singh *et al.* (2021) [12], and Singh *et al.* (2022) [12].

Influence of CFLDs on the adoption of pigeon pea production technologies

Table 3 outlines the impact of Cluster Frontline Demonstrations on the adoption of pigeon pea production technology by farmers. The study revealed a substantial increase of 360.00 percent in the adoption of recommended pigeon pea varieties (JKM 189, TJT 501) after the demonstration period compared to before. Moreover, essential pigeon pea operations such as recommended weed management practices increased by 257.89 percent, followed by the recommended dose of fertilizer (205.45 percent) and plant protection measures (198.39 percent). Adoption of seed treatment with Trichoderma powder @ 5 g/kg seed and Rhizobium culture @ 200 g/10 kg seed increased by 170.91 percent. The adoption rate for land preparation in pigeon pea increased from 80.00% before demonstrations to 100.00% after Cluster Frontline Demonstrations in selected villages. Overall, the adoption level of pigeon pea production technology experienced a remarkable increase of 154.12 percent due to CFLDs organized by KVK, Sagar. This aligns with the findings of Patil *et al.* (2018) [10] and Singh *et al.* (2020) [13].

Effect of cluster frontline demonstrations (CFLDs) on pigeon pea varietal replacement: Cluster Frontline Demonstrations (CFLDs) have proven to be impactful extensions in transforming conventional farming practices. Consequently, efforts were directed towards investigating the replacement of pigeon pea varieties in selected clusters due to CFLDs, and the data presented in Table 4 reveals noteworthy outcomes. Notably, the previously cultivated pigeon pea varieties, particularly the antiquated JA 4 and 'Local' mixed varieties, witnessed extensive substitution with the improved variety TJT 501 in the designated villages. Farmers benefiting from CFLDs observed heightened yields in the demonstration plots upon adopting the improved pigeon pea crop variety. This success motivated them to sustain the adoption of superior pulse crop varieties on a larger scale in subsequent years. This discovery is consistent with the findings of Patil *et al.* (2018) [10] and Singh *et al.* (2020) [13].

Influence of CFLDs on the horizontal expansion of pigeon pea variety TJT 501: This study aimed to evaluate the impact of CFLDs on the horizontal dissemination of the pigeon pea variety through technological interventions. As depicted in Table 5, CFLDs focusing on pigeon pea crops contributed to an enlargement of the area under the improved variety in selected villages. There was a substantial surge in the area, expanding from 12.00 to 75.00 hectares under the pigeon pea variety TJT 501, indicating an increase of up to 525.00% in the CFLDs program. This surge can be attributed to the agronomic attributes of the variety, including high yield and resilience to sterility mosaic virus, wilt, phytophthora, pod borer, and pod fly, as recommended in the state of Madhya Pradesh. These findings align with the research conducted by Patil *et al.* (2018) [10] and Singh *et al.* (2020) [13].

Table 1: Gap in grain yield production of pigeon pea under cluster front line demonstration (C-FLD)

Name of crop	Technology demonstrated	Potential yield of variety (q/ha)	Year	Area (ha)	No. Demo	Average yield (q/ha)		% increase in yield	TG (q/ha)	EG (q/ha)	TI (%)
						DP	FP				
Pigeon pea (Kharif)	TJT 501 + seed treatment with Carbendazim + Thiram @ 1:2 g/kg seed + Rhizobium culture @ 200g/10 kg seed + Imazethapyr 10%SL @ 1 liter/ha at @ 25 DAS + One hand weeding at 45-60 days after sowing/ + Ist spray of Neem oil 0.15% @ 2-3 ml/litre of water at 50% flowering and 2nd spray of Emamectin benzoate 5% SG @ 0.4 g/litre of water at 50% pod filling stage	18	2016-17	30	70	9.83	6.13	+60.36	8.17	3.70	49.00
			2017-18	30	75	8.27	4.40	+87.95	9.73	3.87	54.06
			2018-19	20	50	9.54	6.74	+41.54	8.46	2.80 2.80	47.00
Average/Total				80	195	9.21	5.76	+63.28	8.79	3.46	50.02

Demo.= Demonstration; DP= Demonstrated Plot; FP= Farmers' practice; TG= Technology gap; EG= Extension gap; TI= Technology index

Table 2: Impact of technological interventions on economics of pigeon pea crop under real farm situation

Year	GMR (Rs/ha)		GMR increase over FP (%)	NR (Rs/ha)		NR increase over FP (%)	BCR	
	IT	FP		IT	FP		IT	FP
2016-17	29249	18390	59.05	15699	7540	108.21	2.16	1.69
2017-18	44658	23760	87.95	31758	12860	146.95	3.46	2.18
2018-19	51516	36396	41.54	27516	16396	67.82	2.15	1.82
Total/Average	41860.67	26182	62.85	24991.00	12265.33	107.66	2.59	1.89

IT= improved technological interventions; FP= Farmers' practice GMR= Gross monetary returns; NR= Net Returns; BCR= Benefit cost ratio

Table 3: Impact of CFLDs on adoption of Pigeon pea production technology

Technological interventions	No. of adopters (N=195)		Change in No. of Adopter	Impact (% Change)
	*Before demonstration	*After demonstration		
Land preparation (One cultivator ploughing and 3 ploughing)	156 (80.00)	195 (100.00)	+39	25.00
Recommended Varieties (JKM-189, TJT-501)	35 (17.95)	161 (82.56)	+126	360.00
Seed rate (15 Kg/ha)	115 (58.97)	176 (90.25)	+61	53.04
Seed treatment (*Trichoderma* powder @ 5 g/kg seed) and *Rhizobium* culture @ 200 g/10 kg seed)	55 (28.21)	149 (76.41)	+94	170.91
Time of sowing (First fortnight of June to first fortnight of July)	145 (74.36)	182 (93.33)	+37	25.52
Recommended sowing method (line sowing raised bed 60 x 15cm (R x P)	88 (25.71)	168 (60.57)	+80	90.90
Fertilizer dose (18 N and 46 P_2O^5 Kg/ha)	55 (28.20)	168 (86.15)	+113	205.45
Recommended weed management (Pendimethalin 30% EC @ 3.3 lit./ha as pre-emergence + One hand weeding at 45-60 days after sowing/ Imazethapyr 10%SL @1 lt /ha at @ 25 DAS)	38 (19.49)	136 (69.74)	+98	257.89
Need based Plant protection measure (Ist spray of Neem oil 0.15% @ 2-3 ml/litre of water at 50% flowering and 2nd spray of Emamectin benzoate 5% SG @ 0.4 g/litre of water at 50% pod filling stage	62 (31.79)	185 (94.87)	+123	198.39
Overall Impact				154.12

* Figures in parentheses indicate percentage, ***Source*:** Field survey of 2019-20

Table 4: Impact of CFLDs on varietal replacement of pulse crops

Crop	Previous grown variety	Variety introduced
Pigeon pea	Old and mix variety JA 4	TJT 501

***Source*:** Field survey of 2019-20

Table 5: Impact of CFLDs on horizontal spread of variety of different pulse crops

Crop	Area (ha)		Change in Area (ha)	Impact (% change)
	Before demonstration	After demonstration		
Pigeon pea Variety TJT 501	12.00	75.00	+63.00	525.00

***Source*:** Field survey of 2019-20

Conclusion

The implementation of Cluster Frontline Demonstrations (CFLDs) by Krishi Vigyan Kendra in Sagar, Madhya Pradesh has had a transformative impact on pigeon pea crop yields, both in terms of vertical enhancement and the widespread adoption of recommended crop technologies. Notably, CFLDs resulted in a substantial 63.28% increase in pigeon pea yield. This influence extended to various aspects of crop management, encompassing improved variety utilization, weed control, fertilizer application, plant protection measures, seed rate, seed treatment, sowing methodology, and the incorporation of other recommended pulse crop practices examined in the study. The overall trend of adopting pigeon pea production technologies witnessed a remarkable surge of 154.12% in selected villages. The transition from old mixed pigeon pea varieties to improved cultivars was widespread, with the cultivation area under the TJT 501 variety expanding from 12.00 to 75.00 hectares. In summary, CFLDs emerged as highly effective extension interventions, demonstrating the production potential of pulse crop varieties directly in farmers' fields. The study advocates for the scaling up of CFLDs using a cluster-based approach by extension agencies prioritizing the transfer and application of agricultural technologies on farmers' fields. This approach aims to harness the productivity potential of pulse crops and ensure the swift dissemination of flagship technologies developed by the National Agricultural Research System (NARS). Policymakers are urged to allocate sufficient financial support to the frontline extension system, emphasizing the organized execution of CFLDs under the close supervision of agricultural scientists and extension professionals. The varietal replacement strategy facilitated by CFLDs holds promise in contributing to the escalation of oilseed crop productivity at micro, miso, and macro levels.

References

1. Agricultural Statistics at a Glance. Directorate of Economics and Statistics, Government of India, Ministry of Agriculture, Department of Agriculture and Cooperation, New Delhi; c2022.
2. Directorate of Economics and Statistics (DES). Directorate of Economics and Statistics, Department of Agriculture Cooperation and Welfare, Ministry of Agriculture, Government of India, New Delhi; c2022.
3. Dwivedi AP, Mishra Anupam, Singh SK, Singh SRK, Singh Mamta. Yield gap analysis of chickpea through front line demonstration in different agro-climatic zones of M. P. and Chhattisgarh. Journal of Food Legumes. 2014;27(1):50-63.
4. Dwivedi SV, Anand SK, Singh MP. Varietal performance of oilseeds and pulses at farmers' field in Vindhyan zone under rain-fed condition. *Techno fame* - A Journal of Multidisciplinary Advance Research. 2013;2:25-31.
5. FAOSTAT. www.fao.org/faostat/en/#data/QC. 2021.
6. Joshi NS, Bariya MK, Kunjadia BB. Yield gap analysis through front line demonstration in wheat crop. International Journal of Scientific Research Publications. 2014;4(9):1-3.
7. Kulkarni Shyamrao, Biradar Renuka, Rathod Arvind, Sharanappa Prakash. Impact of frontline demonstration on adoption of improved practices of sunflower (*Helianthus annuus* L.). International Journal of Current Microbiology and Applied Sciences. 2018;7(9):2511-2515.
8. Kumar J, Singh YP, Rana DK. Yield and gap analysis of wheat (*Triticum aestivum*) productivity in NCR Delhi. Indian Journal of Extension Education. 2014;50(1 & 2):56-58.
9. Lathwal OP. Evaluation of frontline demonstrations on black gram in irrigated agro ecosystem. Annals of Agricultural Research. 2010;31:24-27.
10. Patil SS, Mahale MM, Chavan SS. Impact of frontline demonstrations (FLDs) on oilseed crops in south Konkan coastal zone of Maharashtra. Current Agriculture Research Journal. 2018;6(3):355-364.
11. Samui SK, Maitra S, Roy DK, Mandal AK, Saha D. Evaluation of frontline demonstration on groundnut. Journal of Indian Society of Coastal Agricultural Research. 2000;18:180-183.
12. Singh RP, Singh AK, Singh VP, Singh RK, Dixit Deepshikha. Integrated Pest Management Approach in Pulse Crops for Sustainability of Farmers Income. Indian Journal of Agricultural Sciences. 2022;94(4):531-535.
13. Singh AK, Singh RP, Singh RK, Upadhyay SP. Technological Options on Yield Gap Analysis, Economics, Adoption and Horizontal Spread of Pulse Crops. International Journal of Current Microbiology and Applied Sciences. 2020;9(6):3165-3179.
14. Singh AK, Singh RP, Singh VP, Singh RK, Dixit Deepshikha. Site-specific evaluation of pigeon pea (*Cajanus cajan*) variety IPA 203 through participatory approach. Indian Journal of Agricultural Sciences. 2021;91(9):1358-61.
15. Varshney RK, Chen W, Li Y, Bharti AK, Saxena RK, Schlueter JA, *et al*. Draft Genome Sequence of Pigeon pea (*Cajanus cajan*), an Orphan Legume Crop of Resource-Poor Farmers. Nature Biotechnology. 2012;30(1):83-89.
16. Vijaya Lakshmi D, Vijay Kumar P, Padma Veni C. Impact of cluster frontline demonstrations to transfer of technologies in pulse production under NFSM. Bulletin of Environmental Pharmacology and Life Sciences. 2017;6(1):418-421.