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Yield and Economics of Pigeonpea [*Cajanus cajan* (L.) Millsp.] as Influenced by adoption of Technological Intervention under CFLDs in Eastern UP

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ABSTRACT: The cluster frontline demonstration on pigeonpea was conducted three consecutive years during *kharif* seasons of 2018-19 to 2020-21 at farmers' field in participatory mode at different villages of district Azamgarh (U.P.). Despite of proven technologies and high yielding resistant varieties are evolved and also adopted by the pulse growers resulting lower yield and wide technological gaps. Productivity of pigeonpea is still quit lower in U.P. in comparison to several states of country. Considering the facts of low yield of pulses due to technological gap and various other constraints the Krishi Vigyan Kendra, Azamgarh-I (Acharya Narendra Deva University of Agriculture & Technology, Ayodhya) U.P. has conducted technological intervention in three consequently years with proven agricultural technologies of pigeonpea. An area of 40.0 ha covered in nine cluster villages and others of 123 farm families in the district. Among the three years of demonstration, the highest yield was recorded during 2018-19 under both the plots (19.6 & 14.5 q/ha) than remaining years. However, yield obtained during year 2019-20 to 2020-21 was almost similar and far away from the yield of 2018-19. Mean data of grain yield also depicted that demo yield (14.7 q/ha) was found 37.3% superior over control. Variation in the per cent increase in the yield was found due to variation in agro-climatic parameters under rainfed condition. Technology gap analysis reveals that initial year 2018-19 registered markedly narrower gap in comparison to remaining years. A descending trend of technology gap reflects the farmers' cooperation in carrying out such demonstrations. Benefit: cost ratio (BCR) under demonstrations was proved most remunerative and economically feasible against traditional production system.

Keywords: Cluster frontline demonstration, Pigeonpea, Technological gaps, Economics.

INTRODUCTION

Among the pulses pigeonpea [*Cajanus cajan* (L.) Millsp.] is one of the important pulse crop in India. It's having an ability to produce potential yield under limited moisture condition by adoption of proven interventions of pulse production and makes significant crop of rainfed agro ecosystem. The total pulse production in the country in 2018-19 was 3.32 million tons from an acreage of 4.55 million hectare with average yield of 729 kg/ha. In order to make the nation self sufficient in pulses, productivity levels of pulses need to be increased substantially from 598 kg/ha to 1200 kg/ha by 2020 (Ali and Kumar 2005). India is a largest producer & consumer of pulses in the world. However, country is facing shortage of per capita requirement of pulses due to wide gap between demand and production. Uttar Pradesh is also a highly populated state and requirement of pulses is quite higher than remaining states of India. Despite of several biotic & abiotic constraints of pigeonpea production reflects positive indication that productivity of pulses in U.P. is gradually increased after passing of years to reached the level of 1084 kg/ha from 0.25 million hectare area with 0.27 million tons production (Agricultural Statistics at a Glance 2020). The low yield of pigeonpea is not only due to its cultivation on marginal land, but also because of inadequate and imbalanced fertilization, uneven plant population, severe infestation of seasonal and perennial weeds, no adoption of intercultural operations, plant protection measures and climatic variability are predominant reasons to limiting the potential yield of pigeonpea. Therefore, it is imperative to study the performance of technological interventions on pigeonpea under cluster frontline demonstration conducted at farmers' field for obtaining higher yield under rainfed conditions of eastern Uttar Pradesh. The raised bed planting of pigeonpea and implementation of scientific production & protection technologies certainly enhanced pigeonpea production and also minimizing the emerging food safety risk in developing countries with their trade in national market.

METHODS AND MATERIALS

The cluster frontline demonstration was conducted during *Kharif* season of 2018-19, 2019-20 and 2020-21 at selected farmers field in different blocks of Azamgarh district. District located in the VIII eastern plain zone with MSL 77.65 m at 82°40' - 83°52′E, locally equipped with 8 Tahsil, 22 Blocks and around 3721 villages. The average annual precipitation is 1031mm while temperature ranges in between 45.1°C to 5.8°C during summer and winter. In general the soils under study were sandy loam to sandy clay loam in texture with neutral in reaction (7.2 to7.6 pH). The soil test report shows fertility status like available nitrogen, phosphorus and potassium were low to medium only and also deficient in sulphur status. Proven technological interventions were implemented at farmers' field in participatory mode by Krishi Vigyan Kendra (Acharya Narendra Deva University of Agriculture & Technology) Azamgarh (U.P.). A list of farmers was prepared on basis of group meeting and specific skill training was imparted to the selected farmers regarding various aspects on proven technologies. A total of 123 farmers of village Lasra Kala, Sikraur, Sohouli (block Martinganj), Hafizpur, Kishundaspur, Chandeshwar (block Palhani) and Devapar, Harakhpur, Manpur belong to Bilariyaganj block and many other villages were associated under this programme during three years of demonstration. The component demonstration of frontline technology in pigeonpea conducted on improved variety Narendra Arhar -2 with raised bed planting technique keeping 60 x 30 cm plant geometry with the help of planter/manual sowing and thinning which is done manually at 60 days after sowing to maintain intra spacing between plants. A balanced dose of fertilizer was applied @ of 22 kg Nitrogen + 60 kg P_2O_5 per hectare during last planking in the form of diammoniam phosphate along with 20 kg sulphur through zypsum. Use of bio-fertilizer as per method prescribed like PSB, *Rhizobium* & biopesticide *Trichoderma* @ 20, 20 & 10 g/kg of seed as seed treatment were sown in an area of 0.25 to 0.40 ha of each farmer. A sum of 40 hectares area was covered in three consecutive years. Each demonstration were consisting control plot (check) for comparison and also kept where existing farmers practices was carried out (Table 1) by the beneficiaries. All the essential production and protection technologies other than interventions were applied in similar manner in the demonstrated as well as in farmer's practices. Each & every demonstrations were monitored by scientist at different stages of crop growth period to harvest stage.

Table 1: Technological differences between demonstration & farmers practices on pigeonpea.

Sr. No.	Component	Technological intervention	Farmers practices	Gap identified
1.	Variety	Narendra Arhar -2 Certified Seed	Local (Non descriptive)	Full
2.	Seed treatment	*Rhizobium* @ 20 g/kg of seed PSB @ 20 g/kg of seed *Trichoderma* powder @ 10 g/kg of seed	No seed treatment	Full
3.	Fertilizer dose	22 kg N and 60 kg P_2O_5 per hectare (125 kg DAP/ha)	Use of phosphatic fertilizer (100 kg DAP/ha)	Partial
4.	Sowing method	Raised bed planting system	Broadcasting on flat bed system	Full
5.	Crop geometry	Maintained by raised bed planting (RxR – 60 cm & PxP – 30 cm)	Uneven crop geometry	Full
6.	Weed management	Imazethapyr (post emergence) 1.0 liter/ha at 25 days after sowing	No weeding by any means	Full
7.	Gap filling & Thinning	Reseeding performed instead of thinning due to planting system	No gap filling & thinning often performed	Partial
8.	Foliar spray of water soluble fertilizer	Spraying of 18:18:18 NPK @ 5.0 kg/ha before flower initiation stage.	No spraying applied at any stage of crop growth	Full
9.	Plant protection measures	Spraying of Indoxacarb 14.5% SC @ 0.4 Kg/ha at 50 % poding stage	Often applied	Partial

These visits are also utilized to collect feedback information for further improvement in research and extension activities. Similarly, relevant production and protection technologies are comprised in Table 2. The data on yield was collected from both plots at farmers' field by random crop cutting method and analyzed with suitable statistical tools to compare the influence of technological interventions. The minimum support price is used for economic (BCR) calculation purpose. Finally, the recorded data were computed and analyzed for different parameters using following formula (Samui *et al*., 2000) as mentioned hereunder:

Percent increase yield =

$$\frac{\text{Grain yield under FLD - Grain yield under check}}{\text{Grain yield under check}} \times 100$$

Technology gap = Potential yield - Demonstrated yield

Extension gap = Demonstrated yield – Yield under check

Technology index =

$$\frac{\text{Potential yield - Demonstrated yield}}{\text{Potential yield}} \times 100$$

Additional cost of demonstration = Cost of demonstration – Cost of check

Additional returns = Net return in demonstration – Net return in check

Effective gain = Additional return of demonstration – Additional cost of demonstration

India during the period from 2011-12, 2012-13, 2013-14 and 2014-15 in seven villages *viz.* Awunti, Akma, Sikraur, Gopalpur, Chak Khairulla, Pandri and Kotwa covering six block of district Azamgarh. Polybag (disposed plastic glass) technique used for raising of seedlings with an objective to maintain optimum crop geometry by planting of same aged seedlings.

Table 2: General production and protection technologies applied in demonstration field.

Sr. No.	Particulars	Proven technologies
1.	Seed rate	12-15 kg/ha
2.	Sowing method	Raised bed planting (Row to Row 60 cm and plant to plant 30 cm)
3.	Situation	Upland rainfed conditions
4.	Soil type	Sandy loam, Sandy clay loam
5.	Gap filling	Gap filling done after 15 days of planting by using pigeon pea seed
6.	Thinning and Weed management	Post emergence application of Imazethapyr 10 SL @ 1.0 Kg ai/ha at 25 days after sowing and followed by manual weeding once at 45 days after sowing & thinning was done wherever needed at same time
7.	Plant protection	Spraying of Indoxacarb 14.5% SC @ 0.4 Kg/ha at 50 % poding stage

RESULTS AND DISCUSSION

Grain yield analysis. It is evident from the pool data of three years (Table 3) that grain yield under cluster frontline demonstration is drastically fluctuated over the years of demonstration in comparison to traditional production technologies. None of the year is found quit superior in favour of potential yield produced during the evaluation period. Among the three years of demonstration, the highest yield was recorded during 2018-19 under both the plots (19.6 & 14.5 q/ha) than remaining years. However, yield obtained during year 2019-20 to 2020-21 was almost similar and far away from the yield of 2018-19. Mean data of three years of grain yield also depicted that demo yield (14.7 q/ha) was 37.3 per cent superior over conventional production system. The yield reduction during last two years is might be due to heavy rain during last month of September caused prolong stagnation of water and it severely affect plant population which caused yield reduction under both plots. The lowest demo yield (11.4 q/ha) was observed during 2020-21 while change in yield shows highest 45.7% than previous years because it is the function of severe yield loss under control plots which caused by various factors when compared to demo yield on per cent basis. Cumulative effects of all production parameters like improved variety, sowing technique, use of balanced dose of fertilizer, seed treatment with *Rhizobium*, Phosphorus Solublizing Bacteria (PSB) & *Trichoderma*, and adoption of proper plant protection measures effectively enhanced the yield over farmers. The above results are in conformity with the findings of Singh (2002); Singh and Yadav (2008); Mahetele and Kushwaha (2011).

Table 3: Influence of technological intervention on pigeonpea yield and other parameters (pool data of three years).

Year	Area (ha)	No. of farmers	Pigeonpea yield (q/ha)			% change in yield over check	Extension gap (q/ha)	Technology gap (q/ha)	Technology index (%)
			Potential	Demo	Check				
2018-19	20.0	79	28.0	19.6	14.5	35.2	5.10	8.40	30.0
2019-20	10.0	20	28.0	13.1	10.0	31.0	3.10	14.9	53.2
2020-21	10.0	24	28.0	11.4	7.82	45.7	3.58	16.6	59.3
Total/Mean	**40.0**	**123**	**28.0**	**14.7**	**10.8**	**37.3**	**3.93**	**13.3**	**47.5**

Yield gap analysis. Determination of yield gaps and other indices carried out with an objective to educate the farming communities regarding production losses of pulses from national pulse baskets due to ignorance of technological interventions evolved for pigeonpea. Analysis of extension yield gap showed contrary result viz., wider gap 5.10q/ha to during 2018-19 which recorded maximum pigeonpea yield. The wider extension gap was obtained due to positive influence of proven technologies and more conducive years for better pulse production under both practices harnessed growth resources efficiently thereafter resulting higher yield. Drastically lower yield gap under succeeding year indicates that uneven rain pattern equally damaged the plant population resulting lesser yield gap in both plots. Wider extension gap emphasized the need to educate the farmers through various means for the adoption of proven production and protection technologies to minimize the extension gap. Pulse producer should prefer quick adoption of technological interventions developed from research organizations especially for pulses. This result is in conformity with finding of Singh *et al*. (2014).

The technological gap analysis observed to be more informative in respect to demonstration yield subtracting from potential yield expressed real gap in between execution of technologies at farmers' field by the expert and researchers. The analysis on this parameter reveals that only year 2018-19 has recorded markedly narrower technology gap 8.40q/ha than remaining years of demonstration. Mean value analysis of this gap (13.3q/ha) also not much differ from last two year gaps while lower technological gap is associated with previous year. A descending trend of technology gap reflects the farmers' cooperation in carrying out such demonstrations. The technology gap may be attributed to variability & heterogeneity in soil and its fertility status, micro climatic situations, varietal suitability and keenly adoption of latest interventions etc. Technological gap imply researchable issue for realization of potential yield, while the extension gap imply what can be achieved by the transfer of existing technologies. Dwivedi *et al*. (2014) also reported similar trend on chickpea under frontline demonstration.

Technology index showed the feasibility of the evolved technology at the farmer's fields. However, higher technology index reflected the insufficient extension services in respect of technology transfer. The lower value of technology index shows the efficacy of good performance of implemented technological interventions. As per the calculation of index indicates half index (%) values were registered (during 2019-20 & 2020-21) in comparison to remaining previous year. This variation indicates that results differ according to soil fertility status, weather conditions, improper intercultural operations and pest management etc.

Economics. The economic evaluation of technological interventions under cluster frontline demonstrations on various parameters of pigeon pea is depicted in Table 4. In general, it is evident from the calculation that all kind of incurred expanses and returns, both are always higher under demonstration and it also fluctuated independently over the years in of evaluations. By and large, the average gross income generated by adoption of technological interventions was Rs. 85203/ha in comparison to income under farmer practices (check) Rs 62403/ha. As for as the farmers benefits are concern that year 2018-19 is found quit profitable to receive more income (Rs. 91230/ha) due to favorable environment for pulse production. Similarly, the additional net return Rs. 27192/ha (incremental benefits) on per hectare basis was also higher on initial year of on farm demonstration. The economic analysis on net returns reflects that implementation of proven technologies are always registered higher benefits during three years of activities over dominant locally existing practices. It is clear from economic comparison in between additional cost & returns are quite encouraging & clearly reflect by increasing unit cost in pigeonpea production gave up to eight folds more benefits. The additional cost incurred under technological intervention is varied from Rs. 1750 to 2930/ha, while additional net return was positively influenced from Rs. 18550 to 27192/ha. Effective gain on per hectare basis was obtained by subtracting additional cost from additional net return and it was observed highly appreciating (Rs. 25442/ha) in year 2018-19. The benefit: cost ration (BCR) was also higher under technological interventions and traditional practices during initial year than remaining years of pigeonpea production. These findings are in conformity with results obtained by Chaudhary and Thakur (2005).

Table 4: Economic analysis of pigeonpea.

Year	Gross expenditure (Rs/ha)		Additional cost (Rs/ha)	Gross return (Rs/ha)		Net return (Rs/ha)		Additional net return (Rs/ha)	Effective gain (Rs/ha)	Benefit :Cost Ratio	
	Demo	FP		**Demo**	**FP**	**Demo**	**FP**			Demo	FP
2018-19	20000	18250	1750	111230	82288	91230	64038	27192	25442	5.56	4.50
2019-20	21200	18150	3050	75980	58000	57830	38250	19580	16530	4.12	2.94
2020-21	21850	18920	2930	68400	46920	46550	28000	18550	15620	3.13	2.47
Mean	**21017**	**18440**	**2577**	**85203**	**62403**	**65203**	**43429**	**21774**	**19197**	**4.27**	**3.30**

CONCLUSION

On the basis of above technological interventions, it can be concluded that raised bed planting of pigeonpea and implementation of scientific production & protection technologies certainly enhanced pigeonpea production and also minimizing the emerging food safety risk in developing countries with their trade in national market.

Conflict of Interest. None.

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