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# Impact of Frontline Demonstrations on Productivity of Groundnut-Pigeonpea Relay Cropping System in Saurashtra Region of Gujarat

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**ABSTRACT: About 347 frontline demonstrations on pigeonpea in groundnut-pigeonpea relay cropping system were conducted on different aspects *viz*., varietal, fertilizer management, *Rhizobium* inoculation and improved package of practices in seven districts of *Saurashtra* region of Gujarat during last 19 years. Relay cropping in groundnut with pigeonpea was found highly remunerative over the years without any negative effect on yield of sole groundnut crop. In this study of South Gujarat, the technology yield gap between conventional and improved package of practices were much higher ranging from 118 kg ha$^{-1}$ in *Rhizobium* inoculation to 414 kg ha$^{-1}$ with adoption of improved package of practices. This gap is far low as compared to the states of Madhya Pradesh (712 to 817 kg ha$^{-1}$) and Maharashtra (500 to 657 kg ha$^{-1}$). There is urgent need to make the extension services fully functional for educating the cultivators to adopt improved package of practices and recommended technology under existing cropping systems to impart this gap. The economics of the systems also indicates that groundnut + pigeonpea was most profitable system in terms of gross and net returns.**

**Keywords:** Frontline demonstrations, Groundnut, Pigeonpea, Relay cropping, Yield gap.

## INTRODUCTION

Groundnut is one of the major oilseed crops of India accounting for 25% of total oilseed production in the country. It is fairly rich in calcium, iron and vitamin-B complex like thiamine, riboflavin, niacin and vitamin-A (Baraker *et al.,* 2017). Industrialization and urbanization have led to decrease land availability, moreover, farmers primarily focus on cultivation of cash crops like cotton, maize, etc. This production shortage of oilseeds (along with pulses) has led to malnutrition creating a serious consequence to the growing generation. This situation can be overcome by intercropping system which aims at increasing productivity at a particular time, but also insurances against total crop failure (Hussainy *et al.,* 2020). Pigeonpea is an important pulse crop grown in the tropics and subtropics lying between 30°S and 30°N. It occupies 6.5% of the world's total pulses area and contributes 5.7% to the total pulses production. The crop has its origin in India, and spread to African countries more than 4000 years ago (Rao *et al.,* 2010). Pigeonpea is grown in rainfall-scarce regions often on degraded soils, and is a preferred crop in such marginal environments because of its tap root system that allows optimum utilization of soil moisture and nutrients. Traditional pigeonpea cultivars are of medium to long duration (ranging from 160 to 280 days) and are grown as an intercrop with sorghum and cotton which face greater production risks. In other words, pigeonpea provides resilience to the sustainability of production systems and acts as a cushion against income shocks arising due to failure of short-duration intercrops.

The reported area and production statistics of pigeonpea are often underestimated as it does not include its area and production while grown as homesteads as well as under relay crop of pigeonpea in many states like Gujarat, Karnataka and Maharashtra. The homestead production is quite common in many tribal areas of India. The most feasible approach is to raise yield per unit land area, water and capital which can be achieved by providing continuous cropping from beginning of the monsoon season to post monsoon by adopting concept of mixed/inter/relay cropping. Substantial yield advantage can be achieved through inter/relay cropping as compared to mono cropping.

In India pigeonpea is grown in an area of 47.17 lakh hectares with production of 41.37 lakh tonnes. Pigeonpea contribute 17% in total pulses production in India (Chavan *et al.,* 2024). In *Saurashtra* region of Gujarat, *kharif* groundnut is grown as a main crop instead of other pulse crops. But a significant shift in pigeonpea area, production and productivity has been occurred during last two decades. Initially, farmers were not prepared to grow pigeonpea instead of groundnut. The lack of knowledge on cropping system, non-availability of short duration improved varieties, poor extension of latest package of practices (PoP), low seed replacement rate (SRR) and lack of suitable market support were the foremost reasons of its poor adoption among the farmers in the state. The main

pigeonpea grown districts of Gujarat state are *Bharuch*, *Vadodara*, *Surat* and *Panchmahal*. In early 90's the area, production and productivity of pigeonpea was almost negligible in *Saurashtra* region.

The Indian Council of Agricultural Research, has implemented a new fully funded program since mid eighties *i.e.,* FLD's for fast transfer of technology to the farmers field. "Seeing is believing" was the basic philosophy of FLD's. FLD is a distinctive approach to provide a direct interface between researcher and the farmers (Chavan *et al.,* 2024). FLD's on groundnut-pigeonpea relay cropping system including other improved PoP in *Saurashtra* were conducted to increase production of pigeonpea without affecting the yield of groundnut (main crop). The main purposes of these FLD's in this cropping system are: i) to grow pigeonpea crop in such a manner that in any case not adversely affect the sole groundnut crop, ii) to reduce the risk of groundnut crop failure in aberrant climatic conditions and, iii) to obtain the additional net return in least cost of cultivation and to increase the farmers income. Under this unique program, Pulse Research Station unit from JAU, Junagadh, has randomly conducted the FLD's on pigeonpea in seven districts of *Saurashtra* (Gujarat) in the last two decades. The impact analysis of this scheme is presented in this article.

## MATERIAL AND METHODS

Three hundred forty seven FLD's were conducted during *kharif* seasons in last 19$^{th}$ *kharif* seasons at Junagadh, Rajkot, Amreli, Jamnagar, Bhavnagar, Porbandar and Surendranagar districts of *Saurashtra* region of Gujarat at farmers' field (Table 1) to increase the productivity of groundnut-pigeonpea through various types of demonstrations *viz.,* varietal, fertilizer management, *Rhizobium* inoculation and improved and integrated package of practices. All demonstrations were conducted on medium black cotton soils in a block of 0.4 hectares land in order to show better impact of the demonstrated technologies to the farmers and field level extension functionaries. In relay intercropping, short duration intercrop planting is delayed to enable the earlier planted crops opportunity to establish itself (Raza *et al.,* 2020). In groundnut-pigeonpea relay cropping demo's the improved short to medium duration pigeonpea varieties *viz.,* BDN 2, GT 101, ICPL 87119, BSMR 853 and BSMR 736 were sown in rows 90-120 cm apart in the month of mid August in standing groundnut with a seed rate of 12-15 kg ha$^{-1}$. The groundnut crop was sown after onset of monsoon in the month of June-July. The inputs like improved varieties with recommended dose of fertilizers, biofertilizers and insecticides/pesticides and integrated pest management (IPM) kits were supplied to the farmers. Farmers were advised to use proper seed rate and sowing time with recommended package of practices. The seed was treated before sowing with thirum/vitavex @ 2-3 g kg$^{-1}$ of seed as per recommendations to control any infection. Plant protection measures were under taken as per need of the crop. Finally yield data of demonstrations and farmers practices were collected on the equal area.

## RESULTS AND DISCUSSION

**Impact on Seed yield:** The mean data of 167 FLD's on varietal demonstrations on pigeonpea and groundnut seed yield in relay cropping (Table) showed that when pigeonpea was grown as a relay crop with groundnut produced 1464 kg ha$^{-1}$ groundnut pod yield which was close to sole groundnut yield (1580 kg ha$^{-1}$) at farmer's field under varietal demonstration. Apart from it, the farmers also obtained on an average 1299 kg ha$^{-1}$ pigeonpea seed yield as a bonus return without any negative impact on sole groundnut production. The reasons for greater yield under intercropping was that component crops were able to use growth resources rationally and make better use of natural resources than grown separately (Willey, 1979). Further introduction of pigeonpea as a relay crop in groundnut produced pigeonpea equivalent seed yield of 2664 kg ha$^{-1}$. Similarly, in other varietal demonstrations (99) in which improved variety was tested over local cultivars, improved varieties produced higher yield (1916 kg ha$^{-1}$) over local cultivars (1534 kg ha$^{-1}$) in groundnut inter relay cropping system. Use of improved varieties contributed 25.0 per cent higher production than the local one. Hence, farmers were discouraged to use seed of local cultivars and hence adopted the system quickly. Ahlawat *et al*. (1986) reported that in *Saurashtra* region relay cropping in rainfed groundnut, with pigeonpea, sorghum and sesame intercropped 30, 45 and 60 days after sowing (DAS) significantly gave higher equivalent pod yield and net returns than sole groundnut yield. Among relay crops, pigeonpea was found most remunerative irrespective of dates of intercropping. Currently the SRR of pigeonpea in the Gujarat state is 38.0% which is more than Maharashtra (28.01%), Rajasthan and Madhya Pradesh (24.2%) but less than West Bengal (52%) in 2017 (seednet website, 2024). Less seed replacement of crop with lack of new varieties and poor fertilizer management practices may leads to low yield in redgram.

Thirty eight FLD's were taken on judicious and adequate sulphur fertilization (sulphur @ 20 kg ha$^{-1}$) as an improved practice over no application of sulphur (farmers' practice). Pigeonpea seed yield in fertilized and farmer practices were 1955 and 1788 kg ha$^{-1}$, respectively. The per cent increase over farmers practice was to the tune of 9.40 per cent without affecting the main crop (groundnut) seed yield. Shankaralingappa *et al.* (2002) from Bangalore opined that the seed yield and yield components varied significantly affected with the sulphur rate but not with the application method. They reported that basal application of 20 kg S ha$^{-1}$ gave additional monetary benefit (₹ 3156ha$^{-1}$) over farmer's practice. Thirty two demonstrations were conducted on seed inoculation with *Rhizobium* strains *i.e*., a low cost input technology. The average pigeonpea seed yield under *Rhizobium* inoculation was recorded 1859 kg ha$^{-1}$ which was 6.8 per cent higher over without *Rhizobium* inoculation (1741 kg ha$^{-1}$). Dudhade *et al.* (2009) also reported a

9.89 per cent increase in seed yield due to application of *Rhizobium* to chickpea crop.

Frontline demonstrations under application of improved integrated package of practices with plant protection measures (20 kg N + 50 kg $P_2O_5$ 20 kg $K_2O$ + 20 kg sulphur + 20 kg $ZnSO_4$ + two spray of insecticide + installation of bird perches), yielded 2454 kg ha$^{-1}$ pigeonpea seed yield which was 20.30 per cent higher over farmers' practice (2040 kg ha$^{-1}$) and sole groundnut pod yield (1319 kg ha$^{-1}$). This indicated that the transfer of improved technology on these aspects is beneficial for up-liftment of farmer's income without affecting the main crop yield in groundnut-pigeonpea inter relay cropping system. The increasing trend due to this technology was also reported by Rai and Saxena (1995); Desai *et al.* (1999); Meskel *et al.* (2018).

**Yield gains and gaps:** Mean yield data of various type of improved demonstration and conventional practices of pigeonpea was compared to estimate the yield gains and gaps over the years two decades. The yield gaps presently ranging between 118 kg to 414 kg ha$^{-1}$ (Table 2). Under varietal aspect (availability of improved seed), the yield gap was much higher (382 kg ha$^{-1}$) followed by adoption of improved package of practices of pigeonpea (414 kg ha$^{-1}$). The findings are in close conformity with Poonia and Pithia (2011) who reported that in varietal demonstrations of chickpea at farmers field of *Saurashtra* region the technology gap in chickpea varietal trials was much higher *i.e.,* 349 kg ha$^{-1}$ followed by management of fertilizers (191 kg ha$^{-1}$). Gireesh *et al.* (2019) reported that this gap is far low as compared to states of Madhya Pradesh (712 to 817 kg ha$^{-1}$) and Maharashtra (500 to 657 kg ha$^{-1}$).

**Table 1: Number of successful FLD's conducted on groundnut-pigeonpea relay cropping system in *Saurashtra* region.**

| Districts | Years of Successful demonstrations conducted* | | | | | | | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th | 9th | 10th | 11th | 12th | 13th | 14th | 15th | 16th | 17th | 18th | 19th | |
| Junagadh | 03 | 11 | 30 | 15 | 06 | 14 | 07 | 17 | 20 | 20 | 19 | 10 | 17 | 17 | 06 | 0 | 3 | 8 | 9 | **232** |
| Rajkot | 08 | 10 | 01 | 02 | 07 | 0 | 01 | 0 | 0 | 0 | 01 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | **42** |
| Amreli | 0 | 0 | 02 | 0 | 0 | 0 | 02 | 01 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **5** |
| Jamnagar | 01 | 10 | 03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 21 | 0 | 0 | 0 | **52** |
| Bhavnagar | 0 | 0 | 0 | 0 | 0 | 0 | 03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **3** |
| Porbandar | 06 | 0 | 0 | 0 | 03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **9** |
| Surendranagar | 0 | 0 | 04 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **4** |
| **Total** | **18** | **31** | **40** | **17** | **16** | **14** | **13** | **18** | **20** | **20** | **20** | **10** | **29** | **17** | **23** | **21** | **3** | **8** | **9** | **347** |

**Table 2: Mean result of frontline demonstrations (1994-2012) on groundnut-pigeonpea system under different PoP in *Saurashtra* region.**

| Improved aspects/Varieties | No. of FLD's | Yield of groundnut and pigeonpea relay cropping system (kg ha$^{-1}$) | | | PEY** (kg ha$^{-1}$) | Groundnut sole crop yield (kg ha$^{-1}$) | Pigeonpea seed yield in relay cropping system (kg ha$^{-1}$) | | | Technology gap yield (kg ha$^{-1}$) | Economics | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Groundnut (Sole) | Groundnut (Relay) | Pigeonpea (Relay) | | | Improved variety/ practice/ treated | Local variety/ practice/ untreated | % yield gain | | Gross return (₹ha$^{-1}$)* | | Net return (₹ha$^{-1}$) | | | Effective gain |
| | | | | | | | | | | | Improved variety/ practice/ treated | Local variety/ practice/un treated | Improved variety/ practice/ treated | Local variety/ practice/ untreated | Net gain | |
| Variety use in relay cropping system (Var. BDN 2) | 167 | 1580 | 1464 | 1299 | 2664 | - | - | - | - | - | - | - | - | - | - | - |
| Variety use in relay cropping system (var. BDN 2, GT 101, BSMR 853, BSMR 736) | 99 | - | - | - | - | 1315 | 1916 | 1534 | 25.0 | 382 | 42535 | 34055 | 26787 | 19905 | 6882 | 5284 |
| Fertilizer management sulphur @ 20 kg ha$^{-1}$) (BSMR 853, SMR 736) | 38 | - | - | - | - | 1344 | 1955 | 1788 | 9.4 | 167 | 43401 | 39694 | 27536 | 25194 | 2342 | 977 |
| *Rhizobium/PSB* inoculation (Var. BSMR 853, BSMR 736) | 32 | - | - | - | - | 1791 | 1859 | 1741 | 6.8 | 118 | 41270 | 38650 | 26505 | 24525 | 1980 | 1340 |
| Improved package of practices (20:50:20:20:15 kg ha$^{-1}$ N:P:K:S:Zn + *Rhizobium* + weedicide) & IPM (HNPV, *Beauveria*) (Var. GT 101) | 31 | - | - | - | - | 1319 | 2454 | 2040 | 20.3 | 414 | 54479 | 45288 | 36954 | 31159 | 5795 | 2399 |

*Mean selling price (₹/kg): Groundnut (20.70); Pigeonpea (22.20); **PEY- Pigeonpea equivalent yield.

The same trend was also observed in yield gains where adoption of improved seed of pigeonpea showed a greatest impact. Maximum net gain was recorded in varietal demonstrations (₹ 6882) followed by integrated improved package of practices (₹2342). A similar trend was also recorded in effective gain in varietal demonstrations at farmer's field. Clearly the results of all demonstrations over the years indicating a slow pace of transfer of technology and that 20-25% increase in productivity can be achieved through adoption of improved technology and increasing seed replacement rate through spread of improved varieties. The other package of practices may also boost the productivity of the system.

**Effect on Economics:** Economic analysis of the frontline data revealed that mean gross and net returns were influenced considerably by inclusion of pigeonpea as a relay crop in groundnut. The maximum advantage from the relay intercropping of pigeonpea in groundnut was obtained by producing just near to double groundnut equivalent seed yield when compared with 100% sole groundnut yield. In addition the farmers also harvested a good yield of pigeonpea. The mean economic analysis of all demonstrations clearly indicated that highest net return in groundnut-pigeonpea relay cropping was obtained with adoption of improved varieties of pigeonpea (₹26787 ha$^{-1}$) which was 37.3 per cent higher than production potential of local cultivars (₹19905 ha$^{-1}$). The mean net return at farmers'

field with improved package of practices was recorded 18.6 per cent higher over local practices. A low cost input technology of *Rhizobium* seed inoculation may gave 8.1 per cent higher net return as compared to un-inoculated demonstrations The economics of the systems also indicates that groundnut + pigeonpea was found most profitable system in terms of gross and net returns in *Saurashtra* region of Gujarat (Chaudhari *et al.,* 2017). The findings are in close conformity of Khurana and Phutela (1980) who reported that inoculation increased the average seed yield by 9.3 compared with the un-inoculated control. Hence constant efforts are therefore, needed to bridge technology gap through increased seed replacement rate and transfer of technology through various types of demonstrations to educate the cultivators. This will help in enhancing state or countries yield of pigeonpea as well as good source of income for farming community.

## CONCLUSIONS

Out of five package of practices parameters demonstrated at farmers field, adoption of newly released variety of pigeonpea in groundnut-pigeonpea relay cropping system gave economically ₹5284 $ha^{-1}$ effective gain followed by improved PoP with application of (20:50:20:20:15 kg $ha^{-1}$ N:P:K:S:Zn + *Rhizobium* + weedicide + IPM (₹2399 $ha^{-1}$). However, the technology adoption gap in PoP is more as compared to varietal adoption. This may conclude that acceptance of improved verity is better than any other production practices.

## FUTURE SCOPE

High yielding and improved pigeonpea varieties *viz.,* BDN 2, GT 101, BSMR 853, BSMR 736 or other newly released variety with best package of practice and site specific crop management may be used for future transfer of technology and system yield improvement in groundnut-pigeonpea relay cropping. This also results in better resources management and sustainable production.

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