P: ISSN NO.: 2394-0344 RNI No.UPBIL/2016/67980 VOL-4* ISSUE-2* (Part-1) May- 2019
E: ISSN NO.: 2455-0817 Remarking An Analisation

Role of Pigeonpea in Indian Food Security

Abstract

Pigeonpea (Cajanus cajan (L.) Millsp.) is a important tropical grain legume crop grown all over pulse growing area of India. Pigeonpea has a huge hidden potential for qualitative and quantitative improvement in respect of production and nutrition. Among all legume crops, pigeonpea has unique ability of combining optimal nutritional profiles, tolerance to environmental stresses, high biomass productivity and quality contributions to the soil profile in respect of moisture and nutrients. The genepool of legume can be utilized in multiple ways while the high genetic potential in form of variability or diversity exist in both cultivated and wild still have to be explored for further utilization. Gloabally, it has proved that narrow genetic base coupled with low utilization of genetic resources are the principal limiting factors for achieving the target of quality legume production. This article highlights the thrust area for discussing the scope of pigeonpea as a major legume crop in respect of its great role in achieving the food security in Indian context. The important constraints for productivity are discussed along with breeding endeavours along with achievement in India in development of potential pigeonpea cultivars.

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Introduction

The pigeonpea (*Cajanus cajan*), also known as pigeonpea, red gram, tur is a perennial legume from the family Fabaceae. Since its domestication in the Indian subcontinent at least 3,500 years ago, its seeds have become a common food in Asia, Africa, and Latin America Anonymous (2019 & 2021).

It is consumed on a large scale in South Asia and is a major source of protein for the population of the Indian subcontinent. It is the primary accompaniment to rice or roti (flat bread) and has the status of staple diet throughout the length and breadth of India. The centre of origin is probably peninsular India, where the closest wild relatives (Cajanus cajanifolia) occur in tropical deciduous woodlands (Van der Maeson, 1995). Archaeological finds of pigeon pea dating to about 3,400 years ago (14th century BC) have been found at Neolithic sites in Kalaburagi, Karnataka (Sanganakallu) and its border areas (Tuljapur Garhi in Maharashtra and Gopalpur in Orissa) and also the south Indian states such as Kerala, where it is called Tomara Payaru (Fuller and Harvey, 2006). From India it traveled to East Africa and West Africa. There, it was first encountered by Europeans, so it obtained the name Congo Pea. By means of the slave trade, it came to the American continent, probably in the 17th century (Carney. and Rosomoff, 2009).

Pigeonpea is cultivated in tropical and sub-tropical areas between 300N and 300S latitude. It is an important grain legume of Asia (especially, the Indian subcontinent), Latin America and Eastern and Southern Africa. Globally, it is grown on ~5 million hectares (m ha) in about 82 countries of the world (Kumar et al, 2018). Pigeonpea has a unique place in Indian farming and India accounts for about 90% of the global production. It is the second most important pulse crop next to chickpea, covering an area of around 4.42 m ha (occupying about 14.5% of area under pulses) and production of 2.86 mt (contributing to 16% of total pulse production) and productivity of about 707 kg/ha. It is mainly consumed as dry split dhal throughout the country besides several other uses of various parts of pigeonpea plant. It is an excellent source of protein (20-22%), supplementing energy rich cereal diets in a mainly vegetarian population (Saxena et al. 2010)

Pulses are major key factor in nutrient efficiency regarding food security can be highlighted through following facts:

1. Cheap Protein and Mineral sources for rural population
2. Potential for long storability
3. Suitability for marginal environmental conditions

In many countries meat, dairy and fish are expensive and thus out of the reach of many, especially the poor. These populations therefore depend on plant foods to cover their protein needs. Protein and energy deficiencies, in both quantity and quality, are often the culprit for widespread malnutrition, which is manifest in the form of stunting or wasting. In addition, iron deficiency is an important micronutrient deficiency worldwide, especially for people who do not have access to balanced diets (Oppenheimer, 2001). These issues are further compounded as the world's population is growing rapidly and agricultural production must intensify accordingly, if it is to meet global food needs. However, increases in agricultural production must also be sustainable. Pulses are an important source of accessible protein, especially for the smallholder farmers who consume part of their agricultural produce. In fact, the protein obtained from pulses is significantly less expensive compared to animal foods. In some countries, protein from pulses costs much less than the protein sourced from milk. Additionally, the iron absorption of pulses and the protein quality of the diet are enhanced when pulses are eaten with cereals and vitamin C rich foods (Fidler et al., 2004).

There are many drought-resistant pulses, such as pigeon peas (*Cajanus cajan* (L.) Huth), bambara beans (Vigna subterranea (L.) Verdc.) and lentils (Lens culinaris Medik.). These pulses can be cultivated in arid climates that have limited, and often erratic, rainfall of 300-450 mm/year. These are lands where other crops can fail or produce low yields. Additionally, drought-resistant and deep rooting species such as pigeon peas, are not only able to improve food security and nutrition of farmers in marginal environments, but pulses can also supply groundwater to companion crops when planted in intercropping systems (Sekiya andYano, 2004). Therefore, people living in dry environments, where food security represents a huge challenge, can intensify their production systems in a sustainable manner using locally adapted pulses. Nevertheless, appropriate policies and programs to support both the marketing of pulses in local trade systems and modern consumption habits, must also encourage production systems for pulses, in order to increase the availability and consumption of drought-resistant pulses.

As the world's population climbs to 9 billion people by 2050, the questions of food security and protein availability have become paramount to organizations and governments worldwide. According to the United Nations Food and Agriculture Organization, we must produce in the next 40 years the equivalent of all the food produced in the last 10,000 years in order to feed our growing population. Simultaneously, as the world's population grows, its economic demographics have shifted in a dramatic way, with a new middle class growing rapidly in developing economies worldwide. This is particularly true in India, where a booming economy has lifted millions of people out of poverty and into the middle class over the past three decades. While the definition of "middle class" varies, most organizations, including the World Bank, define the middle class as people whose earnings lie between $10 and $100 USD per day.1 By this definition, India's middle class will be made up of approximately 200 million people in 2020, and is expected to expand dramatically over the next decade, reaching up to 475 million by 2030 and creating a middle class larger than that of China, the United States and Europe. With a young population expected to reach 1.6 billion in total by 2022, India is poised to become a leading consumer people by 2050, the questions of food security and protein availability have become paramount to organizations and governments worldwide.

Protein mal-nutrition among the under-privileged masses is an age-old issue and unfortunately, it is on increase due to many factors such as population growth, limited arable lands, expensive inputs, and reduced purchasing power for protein-rich food (Prasad, 2003 & 2013). This situation has resulted in a significant reduction in the average protein intake from 66 g in 1965 to 33 g/person/day in 2005 (Tomar and Talukdar, 2016).

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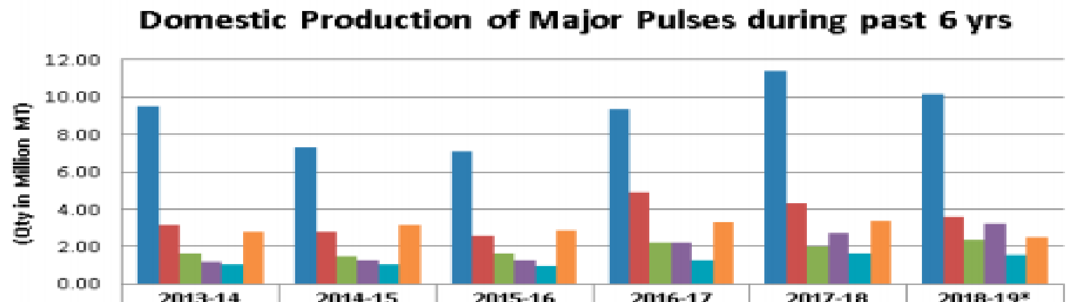

	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19*
Gram	9.53	7.33	7.06	9.38	11.38	10.13
Tur	3.17	2.81	2.56	4.87	4.29	3.59
Moong	1.61	1.50	1.59	2.17	2.02	2.35
Urad	1.15	1.28	1.25	2.18	2.75	3.26
Lentil	1.02	1.04	0.98	1.22	1.62	1.56
Peas	2.78	3.19	2.88	3.31	3.36	2.51

Breeding perspectives of pigeonpea

The success of any crop varieties depends on the factors viz., its utilization, biophysical factors, suitability variety to the adopted cropping systems and moreover concerns about the consumer preferences. In Indian conditions, pigeonpea production systems mainly focused on criteria that include the factors viz., adaptability in cropping systems, marketing of crop, utilizations and consumer preferences.

Breeding legume cultivars for intercropping is a very challenging work. In respect of complex crop like pigeonpea, before initiation of breeding program, breeder needs to take an serious account of required product viz., inbred, variety or hybrid cultivar, or composite populations and the targeted crop production system and related agronomical package of practices.

The consideration regarding the choice of breeding cultivars adapted to different intercropping systems is prime importance.

Low intense-competitive inter crops

This kind of system includes the condition where pigeonpea plants encounter less competition with the companion crops viz., intercropping of pigeonpea with cotton or groundnut, where a larger proportion of land is occupied by cotton/groundnut, and pigeonpea represents only about 25% area, wherein, pigeonpea encounter less competition with major crop due to their thin representation. Pigeonpea is also found good when it is intercropped with fodder sorghum or soybean, as the competition is not of high intensity among these crops. Whereas, Pigeonpea is best option for its quality of auto recovery from the stress of early growth competition and produces fairly good amounts of biomass and seed yield after harvest of fodder sorghum and its found good yielder in soybean based inter cropping system due to the differences in the canopies

High competitive inter-crops

These intercrop system involves combinations of pigeonpea and cereals wherein, the competition between the two crops is intense. It's a big challenge for breeding of high yielding pigeonpea cultivars in such high competitive inter cropping system as it has limiting factor of rapid canopy development of major component i.e. cereals during the rainy season, the growth of pigeonpea plants found to be supressed.

Breeding pigeonpea cultivars for such high competitive inter cropping situation is a real challenge; as upto harvesting of cereal crop the pigeopea crop has face constrains of all most all resources.

Formulation of Inter-cropping system protocol

Since the intercropping systems are quite diverse, no single crop combination could be recommended to carry out breeding activities; and for a long time it has remained a subject of speculation. Some breeders favor the selection and evaluation under sole cropping. In contrast, others recommend breeding under the cropping system for which the cultivar is targeted. This issue perhaps invited discussions for a long time, and therefore, no attempt has been made to review this subject. Byth et al (1981) discussed the issues related to selection environments in length and argued that the selection should be made in the environment for which the end product is targeted. Their argument was based on the facts that (i) the estimation of key genetic parameters vary with the growing environment, (ii) pigeonpea is primarily a long duration crop, and during its life cycle it encounters various stresses, which vary year to year, (iii) heritability of yield is low and genetic advance is not easy to achieve, and (iv) the efficiency of pedigree selection is low due to high inter-plant competition (Green et al, 1981).

Outcome of Pigeonpea Breeding efforts in India

The first scientific pigeonpea breeding effort in India was made by Shaw in 1933 who described morphological and agronomic traits of 86 elite field collections (Shaw et al. 1933). Almost similar efforts were made by Mahata and Dave who identified early and late maturing high yielding types. Such crop improvement activities involving field collections and their evaluation continued for more than two decades without any significant impact on the productivity. Considering high importance of pigeonpea ICAR started All India Coordinated Pigeonpea Improvement Project in 1965.Under these mega project crop improvement activities were simultaneously launched in 31 research centers in diverse agro ecological zones. Till now 120 varieties are released in the crop and currently 26 centers are working under AICRIP on pigeonpea. Systematic crop improvement efforts were also launched at ICRSIAT since its inception in 1972. It focused during first decade (1972 to 1980) on collection, evaluation, maintenance and sharing of germplasm and yield enhancement research. During 1980 to 2000 ICRISAT research priorities were development of stable sources of resistance for wilt and Sterility Mosaic Diseases which are highly devastating and endemic in India in almost all the agro ecologies of pigeonpea cultivation. From 2000, concerted efforts are in progress on CGMS based hybrid development. ICRISAT developed varieties viz., ICP 8863, ICPL 87119, ICPL 85063, ICPL 332, ICPL 84031, ICPL 85010, ICPL 151 and ICPL 88039 which are released by ICAR and NARS partners and are widely popular among all the states of India. ICP 8863 (Maruti) first wilt resistant variety stabilized 3 livelihoods of farmers in central and southern zones. ICPL 87119 (Asha) a wilt and SMD resistant variety widely popular in the country and till today occupies largest area (Kumar et al., 2018).

ICRISAT also released first world GMS based hybrid of the world ICPH 8 in the year 1991. To make hybrid technology commercially viable a stable CGMS system was developed in the crop and this was followed by the development of an economical hybrid seed production technology. So far ICRISAT in collaboration with National Food Security Mission of India, Indian Council of Agricultural Research, and State Agricultural Universities has released hybrids ICPH 2671 and ICPH 2740 for cultivation in India. These hybrids have recorded 30 to 40% yield advantage over varieties in farmers' fields. ICRISAT mission and goal is to develop hybrids for different maturity groups and adaptive to diverse agro ecological niches. Spectacular achievement by ICRISAT in recent past in the crop is deciphering its genome sequence and it has ushered pigeonpea in to genomic era. Subsequently lot of genomic information is in the process of development through molecular approaches like Genome Wide Association Studies (GWAS), Nested Association Mapping (NAM). Multiparent Advance Generation Inter Crosses (MAGIC) and Introgression Libraries (IL) etc. (Kumar et al., 2018)

The achievements of breeding efforts in India can be summarized in Table 1 indicating the major central and state released pigeonpea varieties in India.

Table 1: Pigeonpea Varieties released in India

Variety	Year of Release /Notification	Area of adoption zones/states	Yield (q/ha)	Special feature
TT 401	2007 (CVRC)	CZ, NWPZ	15-16	Indeterminate, early maturity and semi spreading, mid early maturing, resistant to wilt.
PAU 881	2007 (SVRC)	Punjab	12-13	Indeterminate, early maturing, semi spreading, suitable for pigeonpea-wheat cropping system
Pusa 2002	2007 (SVRC)	Central Zone	16-17	Indeterminate, semi spreading, early maturing, suitable for pigeonpea-wheat cropping system
GT 102	2007 (SVRC)	Gujrat	15-16	Indeterminate, spreading, shite and bold seeded, resistant to sterility mosaic disease and tolerant to pod borer and yields about 15-16 q/ha.
GTH-1 (SKNPCH-10)	2007 (SVRC)	Gujarat	17-18	No incidence of SMD ; No. of pods /plant : 260; pod length : 4.9 cm; 100 seed weight : 10.5 gm.
IC-550413	2007 (SVRC)	Central Zone	18-19	Resistant to Fusarium Wilt, Sterility Mosaic Virus, and Mod. tolerant to H. Armigera and Pod Borers,
Jawahar Tur JKM-189	2007 (SVRC)	Madhya Pradesh	19-32	Mode.resistant to Fusarium Wilt, SMD &PB .Tolerant to PBcomplex and PF &Nematodes.
Lam-41	2007 (SVRC)	Andhra Pradesh	12-15	Tolerant to Helicoverpa Pod Borer
Palem Khani (PRG-158)	2007 (SVRC)	Andhra Pradesh	16-18	Resistant to Fusarium Wilt; Plant height : 150-180 cm; Tolerant to drought.
VBN (Rg) 3	2007 (SVRC)	Tamil Nadu	9-13	Pod length : 4 cm ; Seeds/pod : 4 ; 100-seed wt. : 7.5-8.0 gm.
Vipula	2007 (SVRC)	Maharashtra	16-17	Resistant to Fusarium wilts and Mod.resistant to sterility mosaic diseases. Plant Height : 160-170 CM.
VL Arhar-1	2007 (SVRC)	Uttarakhand	18-19	Resistant to wilt and Alternaria Leaf Blight and Rot. susceptible to Blister Beetle.
TJT 501	2008 (CVRC)	CZ (Central)	18-19	Tolerant to Pod Borer & pod Fly

PA 291	2008 (SVRC)	NWPZ (states)	16-18	Tolerant to Phytophthora stem blight & Pod borer
BRG 2	2009 (SVRC)	SZ (State)	12-16	Indeterminate Semi spreading, green podding, bold seeded

If properly stored, pulses remain edible for several years. Farmers have learnt to store pulse seeds with low water content, in dry places, and to discard those seeds that have been attacked by insects or have spoiled. Additionally, pulses show orthodox seed storage behaviour, meaning that they are seeds that are able to germinate after being stored for a long period. In some cases, farmers can store their pulses and then plant them in subsequent cropping seasons (FAO, 2016). Invariably, the farmers who earn their livelihoods from subsistence agriculture adopt intercropping systems to protect themselves from frequent crop failures. According to Willey *et al.* (1981), the sole pigeonpea fails once in five years and sole sorghum once in eight years; but intercropping fails only once in 35 years. However, to increase the productivity and stability, the farmers need adopt improved technologies that could sustain the vagaries of growing conditions. The practice of intercropping is traditionally for subsistence agriculture where the crop growing conditions are not favorable.

Conclusion

At present only a few agronomic recommendations are available for intercropping; therefore, most farmers use their own judgement in choosing the crop combinations and their geometry. Among legumes, pigeonpea is the most favorite intercrop component due to its ability to survive under stressed conditions and accommodate a range of species and plant types as its companion crop. Ideally, to achieve high and stable performance of intercrops the target production environments will need to be re-defined for identifying key eco-regions. These regions will also need to be further characterized for yield potential and risk factors to production using a model-based approach. Such initiatives will give the likely idea of adaptation area, variety and cultural practices for optimizing productivity of the unit area.

To fulfill the nutritional need of our country along with global level the future breeding programmes should be focused with an objective of Due to availability of reference genome by deciphering the genome sequence of the crop in the year 2012, pigeonpea is now equipped with wealth of genomic resources. Diversity analysis of released cultivars in the country indicates the prevalence of limited genetic diversity compared to the vast diversity available in the land races and wild relatives. It offers a very good scope for genetic improvement in the crop by tapping the concealed diversity. Genomic resources now available in the crop are to be exploited to hasten crop improvement. Different approaches are already in progress for crop improvement. Broadly the approaches are enlisted below.

1. Exploration for superior alleles by re-sequencing of wild species.
2. Genomic mapping for drought tolerance and fertility restoration.
3. Development of superior lines through the application of tool of genomic selection
4. Identification of genes of interest associated with hybrid vigour and allied abiotic tolerances using epigenomics

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