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Short Communication

A unique pigeonpea landrace with multiple properties

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ABSTRACT

Diverse landraces play a significant role in breeding sustainable high yielding cultivars with desired traits. This genetic wealth can be used directly as cultivars or as donors for different useful traits. One such landrace of pigeonpea [*Cajanus cajan* (L.) Millsp.] is ICP 7035 that was collected from Bedaghat near Jabalpur (Madhya Pradesh) and is recognized for its sweet immature (vegetable) seeds, immunity to all three races of sterility mosaic virus (PPSMV). It has resistance to multiple diseases and pests of economic importance. ICP 7035 is also useful in soil conservation and has a wide adaptation. This collection is performing well in the sterility mosaic endemic areas of India, Myanmar and Nepal. Considering its qualities, this landrace is considered a 'Jewel' amongst the pigeonpea germplasm and its global demand is very high. Over the last few years ICRISAT has supplied over 300 seed samples to the breeders globally. Direct introductions of ICP 7035 have been released as cultivars in Fiji, China and India.

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Genetic diversity is known to play very significant role in breeding new cultivars and this trait is conserved in landraces in various agro-ecological regions. According to the information assembled by Saxena *et al.* (2016a), a total of 38,753 pigeonpea [(*Cajanus cajan* (L.) M.] germplasm have been collected and characterized by gene ban at various institutes such as ICRISAT, NBPGR etc. This germplasm embraces vast phenotypic and genetic diversity for almost all the qualitative and quantitative traits. From this genetic wealth some out-standing pigeonpea cultivars have been released as direct introductions (Singh *et al*., 2016) and one such germplasm is ICP 7035. This is a unique landrace blessed with various traits useful for breeding new cultivars both for grain as well as vegetable purposes. This landrace is primarily recognized for its large, sweet, immature (fresh vegetable) seeds, resistance to sterility mosaic virus, perennial growth, soil conservation and wide adaptation. Besides describing the key quality traits of the landrace, this research article also discusses its potential role as a donor parent in breeding pigeonpea cultivars.

Collection of Plant material

An isolated plant growing in the wild rocky (with coarse gravel soils) surroundings of Bedaghat (longitude 79.8^{0}E; latitude 23.1^0 N; altitude 353 m), located around Narmada River in the state of Madhya Pradesh, was sighted and some primary data was recorded. A sample of mature pods was then collected and seeds were deposited in ICRISAT Gene Bank where this landrace was allotted the identification number ICP 7035.

Description

Morphological traits

ICP 7035 is an indeterminate short-lived (3-4 years) perennial genotype. It flowers in about 130-135 days and its full seed maturity is achieved in 190-200 days. Its plants grow up to 150-200 cm in the annual cropping system, but as perennials they achieve a height of 250 cm or more. The plant growth and development of ICP 7035 are highly sensitive to both temperature and photo-period fluctuations. The compound leaves of ICP 7035 are large and lanceolate with acute apices. The stem is green and more or less round with apparent ribs. As annuals, the plants produce 5-8 primary branches.

Reproductive traits

Flowers of ICP 7035 are large and dark red in colour. The nectaries are present at the base of the flowers which produce quality nectar as long as the flowers remain open. Petals are imbricate; standard petal is spreading; wing petals are obviate and keel petals are boat-shaped and split dorsally. The corolla is zygomorphic; calyx tube is long; stamens are 10

(9+1) in number and the anthers are ellipsoid and dorsified. The stigma is capitated and glandular, while style is filiform. Its ovary is superior, sub-sessile and ovules are borne on the marginal placenta with a single carpel (Reddy, 1990). Pods of ICP 7035 are smooth, uniformly purple and almost straight with prominent locules (Fig. 1). Each pod has 5-6 seeds. The primary colour of immature as well as mature seeds is purple with irregular speckles on its surface. Its round dry seeds are large (18-19 g/100 seeds) and preferred by commercial millers due to high (85.8%) recovery of quality grade *dal* (Rangaswamy *et al*., 2005).

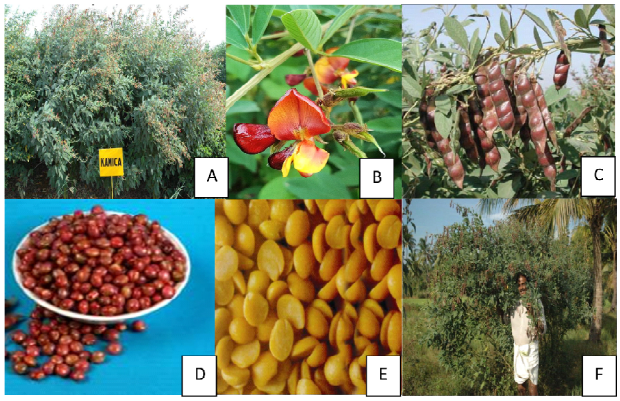

Fig. 1. ICP 7035 A. plants, B. Flowers, C. Pods, D. Immature green seeds, E. Dal produced from ICP 7035, F. Perennial plant on rice bund in Kerala (photo sources: RV Kumar, KP Srijit)

Unique traits

Immunity to all the isolates of Pigeonpea Sterility Mosaic Virus: Sterility mosaic virus is a devastating pigeonpea disease in India, Nepal and Myanmar. It is caused by a virus known as 'Pigeonpea Sterility Mosaic Virus' (PPSMV) which is transmitted by eriophyid mites (*Aceria cajani*). In certain years the yield losses due to this virus in susceptible cultivars have been recorded to be as high as 95% (Reddy *et al*., 1993).

There are three known isolates of this virus (Jones *et al*., 2004). These isolates are prevalent in specific geographical areas and identified as 'Patancheru isolate' (isolate 1), 'Bangalore isolate' (isolate 2) and 'Coimbatore isolate' (isolate 3). Interestingly, there are several of genotypes resistant to isolate 1, but the same is not true for the other two isolates. The virulence of these three isolates is associated with their geographical specificity. The reasons for this specificity are not understood, but it could be linked to the presence of some specific alternate hosts. It has been reported that a genotype found resistant to one type of isolate succumbs to the disease when it is grown in the areas where the other isolate is prevalent. For example ICP 2376 is resistant at Patancheru (against isolate 1) but not at Bangalore and Coimbatore. Similarly, cv. Purple 1 is resistant at Coimbatore (against isolate 3) but not at Patancheru and Bangalore. Among the genotypes tested so far only ICP 7035 stands tall with immune reaction recorded against all the three isolates of PPSMV even under high disease pressure (Jones *et al*., 2004).

Reddy *et al*. (1995) studied leaf anatomy in relation to resistance to *A. cajani*, the vector of PPSMV. They observed that in ICP 7035 the leaf cuticle was thick (3.79 µm) as compared to 1.52 µm in the susceptible genotype. Also, they found that the style of *A. cajani* was shorter than the cuticle thickness of ICP 7035. Hence, the mite vectors cannot penetrate the living epidermal cells of ICP 7035 and failed to transfer the virus in this landrace.

Studies conducted to understand the genetic mechanisms revealed that the resistance in ICP 7035 against strain 1 was dominant and controlled by two non-allelic genes (Srinivas *et al*., 1997a), while for strain 2 a single dominant gene conferred the resistance (Srinivas *et al*., 1997b) to sterility mosaic disease. At present it appears that there is a need to understand the genetic system more clearly and it is necessary that more such studies are conducted using diverse susceptible genotypes.This unique trait (resistance to all three strains) of ICP 7035 makes this landrace a very special genetic material for future breeding and virology research. Also, it has brought back pigeonpea cultivation in several sterility mosaic endemic areas of Karnataka and Telangana in India and Terai (foothills of Himalayas) region of Nepal (C.R. Yadava, per. Comm.).

Resistance to other diseases and pests

ICP 7035 is resistant to other important pigeonpea diseases like *Phytophthora* stem blight (Singh et al., 2013), powdery mildew (Reddy et al., 1993), halo blight (Reddy et al., 1993) and *Alternaria* leaf spot (Rangaswamy et al., 2005). ICP 7035 is tolerant to the devastating insects such as *Helicoverpa* pod borer (Sharma, 2016) and pod fly [*Melanagromyza obtusa* (Malloch)] (Ganguly et al., 2017).

Exceptionally high sugar content

This landrace from Bedaghat has another special trait in its high (8.8%) amount of soluble sugar in green seeds. This value is 77% greater than the other popular vegetable pigeonpea cultivars (Faris *et al*., 1987). The high soluble sugar is highly preferred consumer and

market trait for vegetable pigeonpea; and in fact, it is the highest value ever recorded in any genotype anywhere in the world. For this reason, this landrace has been recognized as the sole donor of high sugar trait for use in breeding new vegetable pigeonpea cultivars.

A study aimed to study the sugar accumulation pattern in ICP 7035 line by Singh *et al*. (1991) revealed that at 24th day from flowering, the sugar content in ICP 7035 was significantly greater than that of the control genotype T 15-15. As the seeds started growing, a gradual decrease in the sugar contents of both the genotypes was noticed, but the differences between the two test lines were maintained, more or less at the same level. These observations suggested that the alleles responsible for the production of soluble sugars start functioning right from the initial stages of seed development and continue to function till physiological maturity is achieved *i.e.* 40-45 days after flowering.

Restricted out-crossing

Natural out-crossing is a bane for pigeonpea since it is the prime cause of genetic deterioration of released cultivars, advanced breeding lines and valuable genetic stocks. Cross-pollination is a common event in this crop; and it is affected by some nectar-hunting insect species such as *Megachile* spp., *Apis mellifera* etc. (Saxena *et al*., 2016b). In most pigeonpea genotypes the average cross - pollination is around 20-25%, and under this situation, it would take only 1-2 generations of open-pollination to destroy the genotypic purity. Pigeonpea breeders for a long time were on the lookout for a genetic solution for this problem and ICP 7035 has proved a boon to them because the flowers of this landrace are abnormal in morphology which restricts the cross-pollination to about 2-3 percent (ES Wallis, pers. comm.). The prime reason for low out-crossing in ICP 7035 is its modified standard margins, which are strongly convolute and overlap in opposite direction at the proximal and distal regions of the calyx. This configuration of petals acts in a manner analogous to a 'zipper' and it not only delays the flower opening until after anthesis has occurred but also makes it difficult for insects to force open the floral buds to cause effective transfer of the foreign pollen (Byth *et al*., 1982). This trait, nick named as 'wrapped flower' is dominant in nature and thus can be transferred easily to elite genetic stocks and cultivars for maintaining their genetic purity.

Strong deep root system and drought tolerance

Being a short-lived perennial, the plants of ICP 7035 are capable of storing substantial amounts of dry matter in their roots (Chauhan, 1993). This not only imparts tolerance against drought but also allows plants to regenerate when damaged naturally or ratooned (cut back) at the half-way of their heights. Its tap-roots grow over 2 m deep with numerous laterals. In perennial plants, however, the roots develop significant secondary growth and grow deeper in search of water to over 3 m or even more (Fig. 2). This besides imparting drought tolerance also helps in holding the soil together and defends the soil against various erosion-causing forces.

ICP 7035 has been released for cultivation in Fiji (as Kamica), China (as Guimu 4). In India, this germplasm has been released in the state of Karnataka, jointly by ICRISAT and Agricultural University, Bangalore as ICP 7035 (Rangaswamy *et al*., 2005).

While concluding, it is important to point out that ICP 7035 is a highly valued pigeonpea landrace. It is an ideal donor for broad-based PPSMV resistance breeding. In this context it is desirable that resistant cultivars are bred at a rapid speed with pointed selections of resistant segregants for one or more PPSMV races. This can be accomplished by integrating some latest molecular tools in the breeding programmes. In the recent developments at ICRISAT the genomics research team has developed a diagnostic kit of single nucleotide polymorphism (SNP) markers associated with PPSMV resistance (Saxena *et al*., 2020). This diagnostic kit is being used to transfer the PPSMV resistance into some elite breeding lines and cultivars of different maturity groups through marker-assisted back-crossing (MABC) and early generation screening (EGS). Overall, ICP 7035 is a prized collection and deserves recognition for its potential role in providing stability to pigeonpea production, principally in the sterility mosaic-prone areas of the Indian sub-continent.

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