



THE FIRST PIGEONPEA HYBRID (PARBATI) FOR THE INDIAN STATE OF ODISHA: ITS BREEDING, YIELD AND SEED PRODUCTION

Clinical Research

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ABSTRACT

Red gram or pigeonpea [*Cajanus cajan* (L.) Millsp.] is a highly valued pulse crop for subsistence agriculture in the state of Odisha, where it is cultivated on 142,000 ha. The productivity level of the present-day pigeonpea cultivars is low and therefore, the annual production of this pulse is short of the state requirements; and it is attributed to the non-availability of high yielding cultivars. To overcome this issue the Department of Agriculture introduced some high yielding varieties and hybrids from ICRISAT. Amongst these, a medium maturing hybrid ICPH 3762 was found outstanding. In 144 on-farm trials conducted in five rainfed districts, the hybrid (1726 kg/ha) was found 112% superior in yield over the adapted local cultivar. This hybrid was released for general cultivation with popular name 'Parbati'. The present paper, besides briefly describing the breeding procedure adopted in developing this hybrid, also discusses the salient features, performances and seed production technology of this hybrid.

KEYWORDS

pigeonpea hybrid, on-farm productivity, adaptation, seed production technology, standard heterosis.

INTRODUCTION

In Odisha (previously Orissa) is the oldest region where *tuar dal* or pigeonpea [*Cajanus cajan* (L.) Millsp.] was cultivated and consumed for centuries to meet the protein requirement of masses. Annually, it is cultivated on 142,000 ha at subsistence level in the state which produces about 115,000 tonnes of grains with the yield about 800-900 kg/ha. Pigeonpea is known to perform well under subsistence agriculture because of its inherent capabilities to grow well under low input conditions, tolerance to drought, and adaptation to various cropping systems. Pigeonpea is also known to improve soil fertility and provide valuable fuel wood. At present the pigeonpea production in the state is insufficient to meet the domestic needs. Since the area under the crop is limited, the enhancement of per unit productivity is the sole answer to increase the harvests. Therefore to achieve this goal, the State Department of Agriculture, in collaboration with ICRISAT made efforts to identify new high yielding cultivars for the farmers. Amongst a number of introductions selected for on-farm testing in five rainfed districts, hybrid ICPH 3762 was most outstanding. This paper briefly describes the (i) breeding procedures adopted to breed this hybrid, (ii) salient features of hybrid ICPH 3762 and its parents, (iii) results of on-station and on-farm trials and (iv) large-scale hybrid seed production technology.

Breeding and Characterization of Female Parent

The technology used in breeding the hybrid ICPH 3762 involved a three-parent system; namely, a cytoplasmic nuclear male sterile (A-) line, its maintainer (B-) line, and a fertility restorer (R-) line. To develop A- line, the primary male sterile source ICPA 2039, that was bred at ICRISAT from a cross involving a wild species (*Cajanus cajanifolius*) and cultivar ICP 28 (Saxena et al., 2005). This male sterile trait was transferred into a medium maturing line ICPL 85063 following the standard backcrossing breeding procedure. To achieve this, ICPL 85063 was crossed (as male parent) with ICPA 2039. All the hybrid plants were completely male sterile; and these were backcrossed to the recurrent parent ICPL 85063. After making three backcrosses in crossing block, the additional breeding activities (backcrossing and selection of resistant plants) were shifted to a wilt and sterility mosaic disease-sick nursery. After completing seven generations of backcrossing to the recurrent parent, the crossed seed was bulk harvested and designated as ICPA 2092. Similarly, the self-pollinated bulk seed of the recurrent parent ICPL 85063 was designated as ICPB 2092.

Plants of ICPA 2092 are non-determinate and semi-spreading in growth with profuse primary and secondary branches. They grow to a height of 170 - 225 cm (Table 1). Flowering in ICPA 2092 is completed in 110 -125 days and the flowers are yellow with red streaks; pods are green with brown streaks. Its cream coloured seeds are round and 100-seeds weigh 10.0-10.5 g. This male sterile line is highly resistant to diseases like fusarium wilt and sterility mosaic virus, but susceptible to pod borer complex. The expression of male-sterility is stable across

locations and years. According to Saxena and Sawargaonkar (2014) ICPA 2092 is a good general and specific combiner for seed yield.

Breeding and Characterization of Male Parent

A perfect male parent restores male fertility in CMS-based hybrid plants. This is an important trait for realizing good and stable yields. Once a fertility restorer gene (*Rf*) is introduced in the recipient male sterile plant it produces specific protein which repairs this abnormality of mitochondrial genome and produce fertile pollen in hybrid plant (Kaul 1988). In pigeonpea, two independently inherited dominant genes (*Rf₁Rf₂*, *Rf₃Rf₄*) control the stable expression of fertility restoration (Saxena et al. 2011).

ICPL 20108 is the male fertility restorer parent of the hybrid ICPH 3762. This inbred line was bred through pedigree selection in a variety breeding programme at ICRISAT. After testing its fertility restoration ability over the seasons and years, it was re-designated as ICPR 3762. The plants of ICPR 3762 are non-determinate, semi-spreading with profuse primary and secondary branches which grow about two meter in height. ICPR 3762 is highly resistant to both fusarium wilt and sterility mosaic diseases. The brown seeds of ICPR 3762 are round and weigh between 10.5 and 10.9 g/100 seeds (Table 1). There is no insect resistance in this genotype.

Synthesis and Characterization of Hybrid

Hybrid ICPH 3762 was produced by crossing ICPA 2092 and ICPR 3762. It belongs to mid-late (180-210 days) maturity duration. The plants of ICPH 3762 are photo-period sensitive, non-determinate, and semi-spreading in growth habit with profuse primary and secondary branches. The hybrid plants develop a huge canopy when sown in the month of June under wide spacing and good moisture regime. The flowers of ICPH 3762 are yellow with light red streaks. The pods are green with brown streaks. Plant height of the hybrid varies between 205 and 240 cm (Table 1). The hybrid, when evaluated in the disease sick nursery, recorded no mortality either due to fusarium wilt or sterility mosaic virus. Deep root system of ICPH 3762 imparts tolerance intermittent drought and produces reasonably good yields under moisture limiting conditions. ICPH 3762 is well adapted to all the major agro-ecological zones of Odisha. Seeds of the hybrid are round, brown, medium bold with high *dal* recovery and hence preferred by millers. Its *dal* is preferred by consumers.

Performance of Hybrid ICPH 3762

Multi-location trials:

The performance of ICPH 3762 in the station trial at Patancheru, where it was bred, was not so encouraging and it varied from year to year. In the multi-location trials conducted in the four districts of Maharashtra (Table 2), yield of the hybrid was fairly good with highest productivity (2844 kg/ha) recorded in Aurangabad. Over all the locations, it recorded 112% standard heterosis over the control cultivar.

On-farm productivity:

The on-farm evaluations of ICPH 3762 in Odisha were sponsored by the Department of Agriculture under a special project and a total of 144 trials were conducted in five districts of Odisha (Table 3). Both the hybrid and control (cv. Asha) cultivar were sown in 1000 m² plots each with recommended cultural practices. The highest number of trials (72) was conducted in Kalahandi district; where the hybrid (2000 kg/ha) produced 149% more yield over the control. Almost similar performance of the hybrid was reported from Rayagadh (2290 kg/ha) and Bolangir (1804 kg/ha) districts. In Boudh and Naupada, however, the hybrid did not perform so well. Over all the test locations, the hybrid ICPH 3762 (1726 kg/ha) was 112% superior to the control in grain production.

This outstanding performance of the hybrid ICPH 3762 in the on-farm trials led to its release by the State Varietal Release Committee for general cultivation in the state of Odisha. The Division of Germplasm Conservation of ICAR – National Bureau of Plant Genetic Resources registered this hybrid as “National Identity Number IC 612565”. In Odisha, the hybrid is popularly called as 'Parbati'.

Large Scale Hybrid Seed Production

An economically viable hybrid seed production technology is necessary for its successful adoption. Under natural field conditions the nectarivore (nectar-hunting) insects such as *Apis mellifera* and *Apis dorsata* carryout the large-scale hybridization in pigeonpea. To demonstrate the seed technology of hybrid ICPH 3762, three pilot production programmes were undertaken, one each in Kalahandi, Naupada, and Rayagada districts. Its salient features are summarized here.

Site selection and field plot techniques:

Seed production of the hybrid was carried out in isolated plots, separated by at least 500 m from other pigeonpea. The other important consideration in selecting the production sites was to ensure that it helped in the buildup and maintenance of an optimum density of insect pollinators. Therefore, attempts were made to select the isolations located near good vegetation (wild or planted) and water bodies which are known to encourage insect activity in pigeonpea field. The focus in designing the field layout was to make fresh pollen available for longer periods and ensure frequent visits of the pollinators to enhance pod setting on the male sterile plants. To achieve this, a ratio of 4 rows of ICPA 2092 (female): 1 row of ICPR 3762 (male) was used. Besides this, a two-meter belt of ICPR 3762 was also planted around the main plot, about two weeks after the sowing of the main plots.

Hybrid yields:

The mean hybrid yield of 725 kg/ha (Table 4) was good enough considering the first such attempt in the state. The highest hybrid seed yield (1125 kg/ha) was recorded in Kalahandi. Further, it is believed that proper training of seed producers in crop management and selection of production sites would certainly help in increasing the hybrid yields in the state, where perennial vegetation is in plenty and the pollinating insects are not limiting.

Sees quality control: In pigeonpea t

The quality of hybrid seed is generally determined using the standard “grow-out test”. In case of pigeonpea hybrids the application of this test is not possible due to its photo-period sensitivity (Saxena, 2015). Therefore, as an alternative an accurate genomics tool has been developed (Saxena et al., 2010). This genomics test is rapid, cost effective and based on simple sequence repeat markers (SSRs) assays for the parental lines (ICPA 2092, ICPB 2092, and ICPR 3762) and their hybrid ICPH 3762.

Summary and Conclusions

In Odisha, about 70% of the people earn their livelihoods from upland rainfed agriculture. In the past few decades, pulses in the state have met with a setback for various reasons that resulted in >50% decline in their area and production. According to recent estimates of the Department of Agriculture, over 50,000 hectares can be brought immediately under high yielding pigeonpea cultivars in the rainfed areas of Rayagada, Kalahandi, Boudh, Bolangir and Naupada districts. Hybrid ICPH 3762 appeared promising with respect to its productivity in a range of environments; and it could provided a life line to the resource-poor rainfed farmers of these districts with >100% gain in the productivity (as recorded by a number of farmers) with no additional inputs. Many farmers of Rayagada and Kalahandi districts were surprised when the hybrid recorded unbelievable yields of over 2000 kg/ha in their fields.

Besides high yield, there was no yield loss due to common pigeonpea diseases like wilt and sterility mosaic virus; and this adds to the stability of production. Some farmers also reported that, in contrast to the traditional cultivars, there were no vacant patches in the hybrid fields. This was due to big size hybrid plants, which covered the space created by early plant losses in the field. With net yield advantage of about 750-1000 kg/ha, and selling price of Rs 50-60/kg, the farmers can easily fetch an additional profit of about Rs 50,000 from one hectare of hybrid crop. In addition, 30% reduced seed rate (because of vigorous canopy) also helped the farmers in offsetting the high seed cost of the hybrid. The magnitude of net profit and yield advantage in pigeonpea hybrids is more or less similar to other hybrid field crops and in the present context; pigeonpea hybrids appear to have a good future in the state of Odisha.

Table1. Key plant and seed traits of hybrid ICPH 3762 and its female (ICPB2092) and male (ICPL20108) parents

Trait	Female Parent	Hybrid ICPH 3762	Male Parent
Days to flower	110-125	121-124	112-120
Days to mature	162-175	180-210	177-185
Plant height (cm)	170-225	205-240	192-210
Seeds / pod	4.0-5.3	4.0-5.2	4.5-5.2
100-seed wt (g)	10.0-10.5	10.5-12.2	10.5-10.9
Seed colour	Cream	Brown	Brown
Fusarium wilt	Resistant	Resistant	Resistant
Sterility mosaic	Resistant	Resistant	Resistant
Helicoverpa pod borer	Susceptible	Susceptible	Susceptible
Maruca pod borer	Susceptible	Susceptible	Susceptible
Dal Protein (%)	21.9	22.4	22.1
Dal recovery (%)	>70	>70	>70
Dal cooking quality	High	High	High

Table 2. Yield (kg/ha) of hybrid ICPH 3762 and its heterotic advantage over the control cultivar in multi location trials

State	District	ICPH 3762	Control cultivar	% Gain
Telangana	Medak (ICRISAT)	2053	1792	14.6
Maharashtra	Aurangabad	2884	2340	23.3
Maharashtra	Parbhani	2187	1814	20.6
Maharashtra	Jalna	1869	1545	21.0
Maharashtra	Phaltan	942	562	67.6
	Mean	1841	1556	18.32

Table 3. Yield (kg/ha) of hybrid ICPH 3762 and control cultivar in the on-farm trials in five districts of Odisha

District	Trials	ICPH 3762	Control cultivar	% Gain
Rayagadh	28	2290	695	231
Boudh	12	803	662	21
Bolangir	11	1804	676	166
Naupada	21	1734	1230	41
Kalahandi	72	2000	803	149
Mean	144	1726	813	112

Table 4. Hybrid (A x R) seed production in Odisha

District	Trial	Area (ha)	Prodn.(kg)	Yield (kg/ha)	Seed ratio
Kalahandi	1	0.4	450	1125	1: 200
Naupada	1	1.0	650	650	1: 130
Rayagada	1	0.5	200	400	1: 080
Total/mean	3	2.9	1300	725	1: 145

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