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Enhancing the livelihoods of Uttarakhand farmers by introducing pigeonpea cultivation in hilly areas

K.B. SAXENA[1], G. SINGH[2], H.S. GUPTA[2], V. MAHAJAN[2], R.V. KUMAR[1], B. SINGH[1], M.I. VALES[1] and R. SULTANA[1]

[1]International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru – 502 324, Andhra Pradesh. India; [2]Vivekananda Parvathiya Krishi Anusandhan Sansthan (VPKAS), Almora – 263 601, Uttarakhand, India; E-mail: k.saxena@cgiar.org

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ABSTRACT

Pilot production demonstrations conducted in Uttarakhand state of India indicated that pigeonpea [*Cajanus cajan* (L.) Millsp.] variety 'VL Arhar-1' (ICPL 88039) can be grown successfully up to the elevations of 2,000 metres. This extra-short duration pigeonpea variety is well-adapted to the agro-ecological conditions of Uttarakhand, and suitable for grain production (up to 1,800 kg/ha) and for soil conservation. The cultivation of pigeonpea, therefore, can be extended into areas predominantly characterized by low soil fertility and inhabited by resource poor farmers. The introduction of pigeonpea in the hills of the Himalayas will help in promoting sustainable and eco-friendly agricultural practices that are cost effective and easy to adopt by the poor farming community. Pigeonpea, being a good source of home-grown high protein food, would directly benefit the nutrition, health and livelihoods of small holder farmers of Uttarakhand. Hence, it is recommended that sincere efforts should be made to promote the cultivation of pigeonpea on a large scale in the slopes and waste lands of this state, and possibly on the hilly areas in India.

Key words: Adoption, Hills, Pigeonpea, Productivity

Over 54% of the total agricultural land in Uttarakhand state is represented by hilly areas. The local topography and limited resources of the state restrict irrigation to only 50,000 ha leaving the remaining 405,000 ha of land entirely depending on rain water. Hence, most crops are grown during the *kharif* season. The productivity of commonly grown *kharif* pulses such as green gram, black gram, horse gram, etc. is adversely affected by various biotic (diseases and insects) and abiotic (low temperature, frost damage, drought) stresses, leading to poverty and malnutrition in the region. At present, the total production of pulses in Uttarakhand is only around 50,000 tonnes, but the annual requirement of pulses in the state is 292,000 tonnes, leaving a vast deficit at the domestic level (Singh *et al.* 2009). This production scenario and escalating prices of pulses often result in protein mal-nutrition, especially among those living below the poverty line. Therefore, to alleviate poverty and ensure food and nutritional security, it is essential to increase production of protein-rich pulses in the state. In order to achieve this, it was necessary to identify, promote and market a pulse crop that could grow well with minimum inputs in the fragile rainfed environments of the hills of Uttarakhand province.

Traditionally, pigeonpea [*Cajanus cajan* (L.) Millsp.] is a minor crop (13,000 ha) in Uttarakhand and the local landraces are low yielding and susceptible to diseases and insects (Singh *et al.* 2009). These landraces mature in 150-750 days, often suffering from low temperature and frost damage and do not permit crop rotation with *rabi* season crops. Hence the pigeonpea area in the province has been limited and remained stagnant over decades. This paper, besides describing the salient features of this variety, discusses on-station and on-farm performance of 'VL Arhar-1' along with its potential impact on the livelihoods of farmers in Uttarakhand.

MATERIALS AND METHODS

Pigeonpea breeders at ICRISAT developed a pure line cultivar 'ICPL 88039'('VL Arhar-1') which can grow successfully in eroded hilly environments (Fig. 1) without disturbing the traditional agriculture systems. 'ICPL 88039' is an extra-short duration (120-130 days to 75% maturity) genotype. It was selected from a cross 'ICP 6' × 'Pant A2' made in 1974 at ICRISAT, Patancheru (India); further breeding was done at ICRISAT's sub-centre at Hissar (Haryana) using the pedigree method. This short duration (76 days) selection was designated as 'ICPL 161' in 1983 with pedigree reading as

Fig 1. 'VL Arhar-1' in demonstration in a valley in Almora

ICPX 740076-46-B_1-1-H_1NDT$_4$-B-B*-B*. Subsequently, further selection within the line was done for earliness at Hissar and, in 1988, a promising extra short duration (68 d) line was identified as 'ICPL 88039' with pedigree reading as ICPL 161-H_2-H_B-H_1-H_1-H_B-H_B. In 2003, 'ICPL 88039' was introduced by VPKAS and subsequently released as variety 'VL Arhar-1' in 2007 for general cultivation in the low and mid hills of Uttarakhand.

'VL Arhar-1' was evaluated in a station trial in 2003. This trial had three replications with plot size of 8.1 m^2. During the next three years (2004–2006), 'VL Arhar-1' was evaluated, along with cultivars 'Manak' and 'UPAS 120' as controls in non-replicated strip plots, each measuring 150 m^2. The sowing in each season was done at the onset of rainy season. A basal doze of 50,000 kg/ha of farm yard manure was mixed with the first ploughing. Row-to-row and plant-to-plant spacing of 40 cm and 10 cm respectively, were adopted. No irrigation or chemical fertilizer was applied to the crop. Among insects, only blister beetles (*Mylabris pustulata* Thunberg) were prominent and were controlled by hand picking. From 2007 to 2010, 'VL Arhar-1' was tested in 1429 on-farm trials in various districts of both Garahwal and Kumaon regions. Since it is a new crop in the region and no other recommended variety was available, no control could be included in the study. To raise a good crop, the farmers were trained in various cultural practices. Data were collected each year only for seed yield. Besides, visual observations (not reported) were also recorded on plant population and growth.

RESULTS AND DISCUSSION

Based on the successful introduction of pigeonpea in the hilly region of southern China (Saxena 2008), a program to explore the possibility of cultivating pigeonpea in Uttarakhand was undertaken. The dependence on cereal diets and limited availability of pulses in the region generally results in protein malnutrition. To overcome this bottleneck some nutritional intervention programmes are needed. Pigeonpea can play an important role in providing valuable protein that is rich in essential amino acids such as lysine and threonine. Pigeonpea, which is a source of high protein food besides having several other associated virtues, may be ideal for domestic use (Yude *et al.* 1993). These factors play an important role in subsistence agriculture and therefore, can fulfil various social, nutritional, economical, and environmental needs of the Himalayan farmers. It is expected that integration of pigeonpea cultivation in different farming systems can pave the way for overall prosperity of Uttarakhand. Since the extended periods of cold and frost can severely damage the foliage and flowers of pigeonpea, its cultivation should be restricted to only low and mid hills.

Besides its extra-short maturity, the variety 'VL Arhar-1' is less photoperiod sensitive as compared to medium-duration varieties of pigeonpea. These aspects together help in its adaptation to the locations characterized by high (up to 2,000m above sea level) altitudes and wide (up to 40^0 N and S) latitudes (Saxena 2008). 'ICPL 88039' is the first variety of its kind among the global pigeonpea cultivars. It is a semi-spreading variety with non-determinate growth habit and plant height of about 150 cm. Its seeds are brown with 100-seed mass of 10.2g (Table 1). To grow a good crop of 'ICPL 88039' on one hectare, about 15-20 kg seed will be required. Its sowing should be done between 20 May and 10 June with inter and intra row spacing of 100 cm and 20 cm, respectively. Since it achieves maturity by mid-October; this provides sufficient time for the sowing of a second crop in the same field. The experiments conducted by VPKAS have showed that 'VL Arhar-1' can also be grown as an inter-crop with soybean, and in the rocky lands (Fig. 2). This variety generally escapes terminal drought and can produce good yields (Table 1).

Table 1. Mean yield and other agronomic traits of 'VL Arhar-1' in on-station trials conducted at Hawalbag during 2003 to 2006

Year	Area	Yield (kg/ha)			% Superiority over	
		VL Arhar -1	Manak (C)	UPAS 120 (C)	Manak (C)	UPAS 120 (C)
2003	Station trial	1,730	930	850	86	104
2004	150	2,120	1,140	910	86	133
2005	150	1,930	1,140	820	69	135
2006	150	2,250	1,030	840	119	168
Total/ mean		2008	1,060	855	89.4	134.9
Days to flower		62*	76	65	-	-
Days to mature		127	151	148	-	-
Plant height (cm)		150	190	120	-	-
Pod length (cm)		5.5	5.5	5.3	-	-
Pods/plant		118	140	105		
100-seed weight (g)		10.2	9.9	6.8	-	-
Protein (%)		21.5	21.9	21.2	-	-

* 2003 data; C: check variety

Fig 2. 'VL Arhar-1' on rocky waste lands in Nainital

Performance of 'VL Arhar-1' in On-farm Trials

Cropping season 2007: A total of 3,020 kg seed of 'VL Arhar-1' was distributed in 13 districts of Garahwal and Kumaon regions during the year 2007 (rainy season) to conduct 1,212 on-farm variety assessment trials (VATs). Seed yield in these trials ranged from 582 to 933 kg/ha with an average of 704 kg/ha. In Garahwal region, 759 such VATs were organized on 94.1 ha. The mean yield of these trials was 715 kg/ha. The highest yield of 933 kg/ha was recorded in Uttarkashi (Table 2). In the Kumaon region, 63.3 ha of pigeonpea demonstrations were conducted by 453 farmers; and on the average, 'VL Arhar-1' produced 691 kg/ha yield. The highest yield (800 kg/ha) was recorded in Udhamsingh Nagar. The overall mean yield of 704 kg/ha, recorded in the first year of trials, was encouraging and it was comparable to the national productivity (700 kg/ha) of the crop.

Table 2. Summary performance of 'VL Arhar-1' in on-farm VATs conducted in various districts of Uttarakhand (2007)

Districts	Villages (no.)	Farmers (no.)	Seed distributed (kg)	Sown area (ha)	Yield (kg/ha)
Dehradun	30	45	320	19	602
Haridwar	39	63	500	25.2	724
Tehri	79	355	325	15.5	741
Uttrakasi	30	171	225	13.7	933
Garhwal	18	43	200	10	582
Rudraprayag	13	23	150	5.7	794
Chanchi	6	59	100	5	630
Total/ mean	215	759	1,820	94.1	715
Nainital	47	83	350	20.5	604
Almora	67	174	215	11.2	625
Champawat	14	74	150	7.2	639
Pithoragrah	53	77	400	20	688
Bageshwar	7	32	60	2.1	788
US Nagar	7	13	25	2.3	800
Total / mean	195	453	1,200	63.3	691
Total/Grand mean	410	1,212	3,020	157.4	704

Cropping season 2008: Seven hundred VATs were conducted on 150 ha land in nine districts of Uttarakhand; but due to some unavoidable circumstances, the results of these trials could not be obtained. However, excellent crop growth and pod set was observed while monitoring visits were made. Nine results obtained are given in Table 3. The highest yield of 1,878 kg/ha was recorded in Chamoli at 1,270 m altitude. In Nainital, 800 kg/ha yield was obtained at 1,630 m altitude.

Cropping season 2009: In 2009, 89 VATs were conducted in 14 villages of Bageshwar district of Uttarakhand. On the average, the yield of 'VL Arhar-1' was 1,023 kg/ha (Table 4). The yields in different villages ranged from 775 to 1,538 kg/ha. In Daulaghat village where five such trials were conducted, 'VL Arhar-1' performed extremely well with a mean yield of 1,354 kg/ha and range of 900 – 1,538 kg/ha.

Table 3. Yield of 'VL Arhar-1' recorded in VATs at different altitudes (2008)

Location	Altitude (m)	Yield (kg/ha)
Dehradun	660	1,679
Pithoragarh	930	1,025
Tehri Garhwal	1,200	1,266
Chamoli	1,270	1,878
Rudraprayag	1,280	1,250
Uttarkashi	1,310	1,266
Almora	1,480	1,275
Champawat	1,580	1,400
Nainital	1,630	800

Table 4. Yield of 'VL Arhar-1' in VATs conducted in Bageshwar district of Uttarakhand (2009)

Village	Demonstrations (no.)	Yield (kg/ha)	
		Range	Mean
Gangori	5	775 – 1,125	954
Dopakhi	1	1,288	1,288
Jakhola	1	775	775
Daulaghat	5	900 – 1,538	1,354
Kunwali	3	913 – 1,338	1,141
Khumati	5	875 – 1,025	935
Darim	14	775 – 1,475	1,008
Pukhral	3	875 – 1,088	958
Ghuna	4	775 – 1,050	896
Tunakotsera	23	775 – 1,400	1,030
Dapolasera	5	800 – 1,075	918
Bhadora	7	838 – 1,200	966
Manan	6	875 – 1,250	1,133
Doragiri	7	875 – 1,000	932
Total/mean	89	775 – 1,538	1,023

Cropping season 2010: In 2010, 119 on-farm trials were conducted in 20 villages of Bageshwar, Nainital, and Almora districts. The yields recorded in these villages ranged from 562 to 1,843 kg/ha with a mean of 1,280 kg/ha. In Karala village, where 29 trials were conducted, 'VL Arhar-1' performed very well with a mean of 1,500 kg/ha and range of 850–1,843 kg/ha (Table 5).

Overall performance of 'VL Arhar-1': The results of 1,429 on-farm VATs conducted in various districts of Uttarakhand (Table 6) over the past four years (2007- 2010) have given a strong indication of high adaptation of the pigeonpea variety 'VL Arhar-1' in the hills of Uttarakhand. In the first year, the yield levels were low due to poor knowledge of crop husbandry; but in the subsequent years its performance levels were higher because of timely sowing and better control of insects. At some locations, 'VL Arhar-1' produced as high as 1,800 kg/ha of grains. In these trials, 'VL Arhar-1' showed good potential in low and medium hills. This variety was also evaluated under organic culture at Almora (VPKAS), Chiniyalisour (KVK) and Majhera Farm of G.B. Pant University

Table 5. Yield of 'VL Arhar-1' in VATs conducted in Uttarakhand (2010)

Village	Demonstration (no.)	Yield (kg/ha)	
		Range	Mean
Nag	46	620-1450	1050
Garampani	1	1232	1232
Kakrighat	2	1300-1325	1313
Petsal	6	700-1350	875
Tipolsera	17	865-1325	1066
Chaana	10	663-1300	898
Kotli	2	980-1085	1033
Govendpur	1	1200	1200
Dwarahat	1	810	810
Dania	3	685-1205	930
Gagas	17	562-1525	1023
Dosa	3	650-950	833
Bheta	5	980-1255	1082
Hawalbagh	1	1180	1180
Sainar	1	1090	1090
Ranikhet	2	925-1105	1015
Sall	1	1075	1075
Kasson	1	1400	1400
Karala	29	850-1843	1500
Total/mean	119	562-1843	1280

Table 6. Overall performance of 'VL Arhar-1' in the VATs conducted in Uttarakhand (2007-2010)

Year	Demonstration (no.)	Yield (kg/ha)	
		Range	Mean
2007	1212	582-933	691
2008	9	800-1878	1315
2009	89	775-1538	1023
2010	119	562-1843	1280
Total/mean	1429	562-1878	1077

of Agriculture & Technology. In the on-station trials (Table 1), on the average, 'VL Arhar-1' yielded 2008 kg/ha over four years (2003-2006) and it recorded 89.4% yield advantage over the best check 'Manak'. It ('VL Arhar-1') matured in 125 to 130 days, 24 days earlier than the check variety 'Manak'.

Profitability of pigeonpea in relation to rainfed rice (Oriza sativa L.) and mandua (Elusine coracana): The profitability of any crop production system is determined by estimating the cost incurred in producing the crop and the gross returns accrued from it. The total production costs of pigeonpea, rice and *mandua* under rainfed conditions were comparable (Table 7). The costs to cultivate pigeonpea included farm yard manure (32.7%), land preparation (12.3%), harvesting and threshing (10.6%), seed (10.6%), plant protection (9%), intercultural operations (8.2%), miscellaneous (10%), interest of working capital (4.3%), and sowing and thinning (2.3%). The total costs amounted to Rs. 14,527 per hectare for pigeonpea, Rs. 15,358 per hectare for rainfed rice and Rs. 12,541 per hectare for *mandua* cultivation. The total value of the gross produce involving seed, sticks and straw was estimated at Rs. 53,700 per hectare for pigeonpea, Rs. 23,950 per hectare for rice and Rs. 19,270 per hectare for *mandua*. The net returns were Rs. 39,173 per hectare from pigeonpea, Rs. 8,692 per hectare from rainfed rice and Rs. 6,729 per hectare from *mandua*. Accordingly, the benefit cost ratio for pigeonpea (3.69) was significantly higher than rainfed rice (1.56) and *mandua* (1.54).

CONCLUSIONS

The performance data indicated that variety 'VL Arhar-1' can play a potential role in the economic growth of the farming community of the state. Since the cultivation of pigeonpea does not require high inputs and the grains have good market value, the probability of its adoption by Uttarakhand farmers is always high. The adaptation of variety 'VL Arhar-1', particularly at low and medium elevations (up to 2,000 m above sea level), showed its potential in diverse environments of rainfed Himalayan agriculture. In general, the soils of such habitats are shallow and often infertile with low water holding capacity and it is rather difficult to grow any other food crop profitably. Hence, efforts should be

Table 7. Comparative profitability (Rs/ ha) of cultivating rainfed pigeonpea, rice, and mandua in Uttarakhand

Item	Pigeonpea	Rainfed rice	*Mandua*
Gross income (Rs/ ha)			
Seed (yield x rate Rs/qtl)	16 x 3000 = 48,000	23 x 950 = 21,850	18x915= 16,470
Straw	10 x 70 =700	30 x 70 = 2,100	40x70 = 2,800
Sticks	50 x 100 = 5,000	nil	nil
Total	53, 700	23, 950	19, 270
Production Cost (Rs/ ha)			
Variable cost	12, 227 (84%)	12, 859 (85%)	10, 241 (82%)
Fixed cost	2,300 (16%)	2, 300 (15%)	2,300 (18%)
Total	14,527	15, 358	12, 541
Net returns (Rs/ ha)	39, 173	8,692	6, 729
Benefit : Cost ratio	3.69	1.56	1.54

continued to promote a crop like pigeonpea which has potential for high profits. Since Uttarakhand is a notified organic state, the cultivation of pigeonpea can also be promoted with recommended organic farming practices. To achieve this, the farmers can be trained in integrated crop management technologies. Since pigeonpea is a new commercial crop for Uttarakhand, it is essential to develop efficient marketing systems involving local farmers and traders; this will prevent distress sale of the produce and optimize the profits.

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