Date of sowing had no effect on time to flower but late-sowing shortened slightly days to maturity (Table 1). Genotypes that produced seed matured within 130 days, with ICPL 4 maturing earliest. Late sowing resulted in taller plants, with seed-producing genotypes reaching heights of between 0.5 and 1.4 m (Table 2). Pods $plant^{-1}$ increased with later sowing and for the different genotypes ranged between 20 and 35 pods $plant^{-1}$ (Table 2). ICPL 84052 had the highest number of pods $plant^{-1}$. All pods formed were severely infested by podfly, for all genotypes at each sowing time in both seasons. Grain yields were highest for the early sowing but were generally at low levels (divided by 100 to estimate t ha^{-1}, which did not exceed 0.5 t ha^{-1} for any genotype) (Table 2).

Thus, it is possible to identify short-duration pigeonpea genotypes that can grow reasonably well, produce an acceptable number of pods $plant^{-1}$ and mature in a relatively dry period in rice fallows of Chittagong district. However, grain yields were very low for all genotypes at each sowing in each season, which can be attributed to the severe infestation of podfly. Little control of this pest could be obtained by insecticide spraying. There would be little prospect of farmers of this region adopting insecticide spraying for pulses, even if an effective spraying regime could be identified, because of the low input status assigned to pulses generally. Thus, any prospect for growing short-duration pigeonpea as a rice fallow crop in Chittagong district would depend on development of genotypes truly resistant to podfly damage.

References

Lawn, R.J., and **Troedson, R.J.** 1990. Pigeonpea: Physiology of yield formation. Pages 179–208 *in* The Pigeonpea (Nene, Y.L., Hall, S.D., and Sheila, V.K. eds.). Wallingford, Oxon, UK: CAB International.

Virmani, S.M., Faris, D.G., and **Johansen, C.** 1991. Agroclimatology of Asian grain legumes (chickpea, pigeonpea, and groundnut). Research Bulletin no.14. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 77 pp.

Exploring Novel Cropping Options for Pigeonpea in Chittagong District, Bangladesh. II. Adaptation to Hilly Areas

S K Roy[1,2], **J U Ahmed**[1], **P K Biswas**[1], **R R Saha**[1], **A F M Maniruzzaman**[1,3], and **C Johansen**[4] (1. Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, Bangladesh; 2. Present address: Flat 1/502 Cashel Street, Linwood, Christchurch, New Zealand; 3. Present address: 264/2A West Dhanmandi, Eidgah Road, Old Road No.15, Dhanmandi Residential Area, Dhaka 1209, Bangladesh; 4. ICRISAT Asia Center)

Chittagong district mainly comprises hilly regions subject to ever-increasing devegetation, with the consequence of soil erosion and nutrient loss. This is exacerbated by an annual rainfall of 3000 mm or more. Agricultural productivity in such regions is low, particularly during the rainy season. Thus, increased use of a grain legume crop that can stabilize the soil, increase organic matter and add fixed nitrogen to the soil should be advantageous. Pigeonpea is a strong candidate in this regard. However, this crop is particularly susceptible to excess soil moisture conditions, likely in such a high rainfall region. But the soil type in these hilly areas is mainly of sandy-loam texture, and thus infiltration and drainage of excess moisture should be facilitated.

It was therefore decided to examine adaptation of pigeonpea to such hilly areas. It was hypothesized that medium-duration genotypes (150–200 days) are best suited, to be sown near the beginning of the rainy period (i.e., May) and the grain to reach maturity after cessation of the main rains (i.e., Nov). At Hathazari, 95% of total annual rainfall (3200 mm) is received during the monsoon season of Apr to Oct, with a peak of 842 mm in Jul. Thus, in the first instance, a range of genotypes, mainly of medium-duration but also including some short- and long-duration genotypes, were evaluated at two sowing dates.

Experiments were conducted in the hilly orchard area of the Regional Agricultural Research Station, Hathazari, Chittagong district, Bangladesh. The soil was sandy loam with pH 5.5 and the site well-drained. In 1989/90, a split-plot experiment with three replications was conducted. Sowing dates of 16 May and 20 Jun 1989 were assigned to main plots and a set of 30 genotypes, comprising 8 short-, 20 medium-, and 2 long-duration genotypes, were assigned to subplots. Subplots consisted of 2 rows each, 3-m long. Interrow spacing (subplots were contiguous) was 45 cm and intrarow spacing 15 cm for all genotypes, giving a plant population of 15 plants m^{-2}. After thorough preparatory tillage, a basal application of 25 kg P ha^{-1} as triple superphosphate, and 10 kg S ha^{-1} as gypsum was applied. Seeds were inoculated with *Rhizobium* culture and hand dibbled at 2–3 seeds $hill^{-1}$, with emerging seedlings subsequently thinned to 1 $hill^{-1}$. At 45 days after sowing (DAS) the crop was topdressed with 20 kg N ha^{-1} applied as urea. The crop was maintained weed free and grown rainfed.

In 1991/92, 10 short-duration pigeonpea genotypes were evaluated at the same site, when sown during a break in the monsoon season, i.e., on 9 Jul 1991. A randomized complete block design with three replications was used. Plot size consisted of 4 rows, each 4-m long. Interrow spacing was 50 cm (subplots were contiguous), and intrarow spacing 20 cm, to give a plant population of 10 plants m^{-2}. After soil tillage, basal applications of 13 kg P ha^{-1} and 10 kg S ha^{-1} were given in the forms previously mentioned. A topdressing of 20 kg N ha^{-1} as urea was applied at 18 DAS as symptoms of nitrogen deficiency were apparent then. *Rhizobium* inoculum was not applied at sowing because of its nonavailability. Plots were kept weed free, and well drained to avoid standing water. Dimecron® was sprayed at fortnightly intervals from flower initiation to late podding in an attempt to control pod borers.

In the 1989/90 experiment, time to maturity of short- and medium-duration genotypes at both sowings was

Table 1. Time to maturity, final plant height, and grain yield of all short- and long-duration genotypes tested, and the 8 highest yielding of 20 medium-duration pigeonpea genotypes tested on two sowing dates[1] in a hilly area at Hathazari, Chittagong district, Bangladesh.

	Time to maturity (days)		Plant height (cm)		Grain yield (g m^{-2})	
Genotype	D_1	D_2	D_1	D_2	D_1	D_2
Short duration						
ICPL 87	159	205	170	112	56	33
ICPL 151	150	184	160	106	45	27
ICPL 161	150	173	250	196	54	60
ICPL 83024	163	180	180	123	112	80
ICPL 84031	155	170	161	111	48	67
ICPL 84052	150	170	237	151	90	63
ICPH 8	160	175	259	191	70	82
UPAS 120	170	175	269	180	66	69
Medium duration						
ICPL 270	218	205	255	178	71	92
ICPL 8863	224	210	280	210	76	94
ICPL 84060	224	215	302	207	82	89
LRG 30	209	215	303	206	88	68
HY 14	218	190	278	227	82	88
PDM 1	218	203	297	225	89	81
MRG 53	234	220	262	225	85	88
BDN 12	239	220	259	212	78	82
Long duration						
ICPL 366	255	238	272	200	87	87
Bahar	253	235	235	256	86	88
LSD (P = 0.05)[2]	-	11	7.3			
CV (%)[2]	-	15.0	12.8			

1. D_1 = 16 May 1989; D_2 = 20 Jun 1989.
2. Values for all 30 genotypes tested.

considerably longer than that obtained in the respective adapted environments for these genotypes in India (Table 1). Vegetative growth of all genotypes tested was profuse, as indicated by plant height data. Nodulation, examined in one replication at 50 DAS, appeared reasonable for pigeonpea but with much greater nodulation at the first than the second harvest. Most genotypes had grain yields of at least 70 g m^{-2} (which extrapolates to 0.7 t ha^{-1}) at one of the sowing dates at least, but only short-duration genotype ICPL 83024 at the early sowing exceeded 100 g m^{-2} (1.0 t ha^{-1}).

In the 1991/92 experiment, early reproductive growth coincided with a period of heavy rainfall; over 300 mm rainfall was received in mid-Oct, as compared to the long-term average for that period of around 100 mm. Thus flowers were dislodged and insecticide sprays were ineffective against *Maruca testulalis,* which attacked the pods that did manage to form in Oct. Therefore, grain yields recorded were from second, or even third, reproductive flushes. Harvesting of matured pods of all genotypes was completed by 12 Feb 1992. Consequently, times to flowering and maturity could not be accurately recorded in this study. Due to the later sowing of this experiment, extent of vegetative growth, as indicated by plant height (Table 2) was not as much as obtained for common genotypes grown in 1989/90. Grain yields in 1991/92 were of the same order as in 1989/90, with only ICPL 85045 exceeding the equivalent of 1.0 t ha^{-1} (Table 2).

Table 2. Final plant height and grain yield of 10 short-duration pigeonpea genotypes grown in a hilly area at Hathazari, Chittagong district, Bangladesh, 1991/92.

Genotype	Plant height (cm)[1]	Grain yield (g m^{-2})
ICPL 151	118 c	99 a
ICPL 83006	112 c	73 cd
ICPL 83015	90 d	65 cd
ICPL 87023	77 e	59 d
ICPL 85014	115 c	94 ab
ICPL 85045	187 a	101 a
ICPL 86009	151 b	70 cd
ICPL 86020	141 b	85 ab
ICPL 89008	124 c	80 bc
Manak	111 c	100 a

1. Means not followed by a common letter differ significantly at $P = 0.05$, according to Duncan's Multiple Range Test.

In both seasons, vegetative growth was prolific, and plant stand was maintained, indicating that pigeonpea could adequately form biomass in this high rainfall environment despite its susceptibility to waterlogging damage. This could be attributed to the sandy loam soil texture which permitted rapid infiltration of rain water. However, considering the amount of biomass produced and the extended crop duration, yields were generally disappointingly low, when compared with yield potential of these genotypes in their original environments (3 t ha^{-1} or more). One reason could be the high rainfall causing flower drop and reduced pod set of the first flush of short- and medium-duration genotypes. Another reason would be damage to the first reproductive flush by *Maruca testulalis*, with again rainfall interfering with attempts to achieve control by insecticide spraying. However, pods matured early enough not to be affected by podfly (*Melanagromyza obtusa*), as happens to pigeonpea planted in rice fallows in Dec or Jan in this area (see Part I of this paper, in this issue). Nevertheless, second flush recovery was low compared to what can be achieved at lower latitudes, such as at ICRISAT Asia Center (Johansen et al. 1991). Lower second flush yields are likely to be associated with lower winter temperatures at Hathazari (monthly average of daily maximum/minimum temperatures for Dec and Jan are 27.7/13.8 and 22.9/11.7°C).

An additional reason for the low grain yields obtained could be use of inappropriate spacing. For medium- and long-duration genotypes, plant population seemed to be too dense, thus minimizing branching (i.e., sites of pod formation) and light penetration for developing pods. For short-duration pigeonpea of determinate growth habit, the population used in the present studies appeared too sparse; indeed at denser populations higher yields can be obtained (see Part III of this paper, in this issue).

The results obtained so far indicate a need to study further date of sowing, with both short- and medium-duration genotypes, so as to identify a system that would permit first flush development in the Nov–Dec period, when the monsoon rains have abated. The ratooning capability of some short-duration genotypes (Johansen et al. 1991) would render these as candidates for rainy season cropping in this region even if the first flush is lost to rain and/or insect damage.

Reference

Johansen, C., Chauhan, Y.S., Gupta, S.C., and **Taylan, F.M.** 1991. Assessing short-duration pigeonpea for multiple harvest potential. International Pigeonpea Newsletter 10:3–6.