

## BREEDING PROGRAMMES FOR IMPROVING QUALITY OF PEPPER AND PEPPER PRODUCTS

K.V. Peter, P.N. Ravindran, B. Sasikumar and T. John Zachariah

Indian Institute of Spices Research, Calicut 673 012, Kerala, India

Black pepper, the "King of Spices", reigns supreme in the spice trade all over the world. The ancient Aryans used it as a remedial and curative agent against dyspepsia, malaria and haemorrhoids. The Egyptians used it for embalming. The Asians used it as aphrodisiac. The Dutch and French housewives used it as an insect repellent and moth killer. Pepper has become an integral part of American, Continental, Arabic, Asian and Oriental cuisine. Black pepper is the dried mature fruit of the perennial climber *Piper nigrum* L., a native of the humid tropical forests of the Western Ghats from where it spread throughout the tropics. *P. nigrum* belongs to the genus *Piper* and family Piperaceae. Over a thousand species are included in this genus, out of which about 110 are of Indian origin. The major centre of diversity is Northern South America. In India, the North-Eastern region and the South Western region are recognized as two independent centres of distribution of *Piper*. The earliest record of description of *Piper* spp. of the Kerala region, which is the centre of origin and diversity for black pepper, was by Rheede (1678) in his *Hortus Indicus Malabaricus*, in which he described five types of wild peppers including black pepper and long pepper. The first major study on the Indian *Piper* was by Hooker (1886) in his Flora of British India. He divided the genus into six sections. Rama Rao (1914) in his Flowering Plants of Travancore listed 14 species of *Piper* from Western Ghats. Fischer (1921) described six species from Anamalai Hills. The most authentic floristic study was that of Gamble (1925) who in his Flora of Presidency of Madras described 14 species of *Piper* with keys. The other floristic enumerations were those of

Saldahna and Nicholson (1978), Rao and Razi (1981), Rahiman (1981) & Ravindran (1990). New taxa were reported by Ravindran *et al* (1987), Velayudhan and Amal Raj (1992) and Nirmal Babu *et al* (1993). The species diversity of *Piper* in South India is given in Table 1. Ravindran (1990) and Ravindran *et al* (1992) & Ravindran and Nirmal Babu (1994) carried out detailed biosystematic studies on black pepper and related taxa.

### CYTOLOGY

Mathew (1974) studied 11 cultivated and six wild types of *P. nigrum* and found the somatic chromosome number of  $2n=52$  in all the cultivated and wild, except two (wild accessions) in which the chromosome number was  $2n=104$ . The chromosome length ranged from 1-3. Nair *et al.* (1993) reported a triploid black pepper cultivar ( $2n=78$ ).

Reports on chromosome number of *Piper* spp., ( $2n=24, 26, 36, 39, 40, 48, 52, 60, 64, 65, 68, 78, 80, 96, 104, 132$ , etc.) indicate clearly the existence of a polyploid series. All the species studied from South India and Sri Lanka could be traced to a common basic number of  $x = 13$  (Jose and Sarma, 1985). The North Indian species seem to have a basic number  $x=12$ . The haploid number  $n=12$  as seen in *P. cubeba* may represent comparatively a primitive number from which  $x=13$  might have evolved. Jose and Sharma (1985) suggested that  $x=13$  reported consistently, should be taken as the valid basic number of the genus. The species with  $2n=26$  are taken as diploids, those with  $2n=52$  as tetraploids, and  $2n = 104$  octaploids. The

chromosome number in *P.mullesua* ( $2n=132$ ) may be a decaploid (Ravindran and Nirmal Babu, 1994). Lack of uniformity in the reports of chromosome number by different workers indicate existence of many cytotypes in this taxa. These cytotypes are being maintained in the population by the predominant vegetative propagation. An induced tetraploid line has also been developed at IISR (Nair *et al*, 1993)

#### BREEDING FOR HIGH QUALITY

Black pepper cultivars rich in piperine, oleoresin and essential oil are in great demand. Evaluation of the germplasm collections has resulted in identifying high piperine and oleoresin types as well as high oil types. Variability for quality characters of black pepper are reported (Table 2). Gopalam & Ravindran (1986) categorized black pepper cultivars based on quality parameters (Table 3). Gopalam *et al.* (1991) also classified black pepper cultivars based on berry size such as large, medium and small (Table 4). These authors also recorded good variability for chemical quality parameters in black and white pepper from popular black pepper varieties (Table 5).

#### BREEDING FOR HIGH YIELD

Primary objective in black pepper breeding is increased yields. Evolution of high yielding varieties coupled with disease resistance forms the basic tenant of pepper breeding goals. Lately, efforts are diverted towards achieving such diverse objectives like tolerance to biotic and abiotic stresses, adaptability to specific altitudes, high content of oleoresin, bold berries and stable yield over seasons (Sukumara Pillai *et al.* 1994).

Black pepper is predominantly self pollinated due to geitonogamy (Sasikumar *et al.* 1992). The conventional breeding methods followed in black pepper are

introduction, selection, hybridization and mutation breeding (Table 6).

Heterosis breeding has been successfully used in pepper. 'Panniyur-1' and 'Panniyur-3' are the  $F_1$ s released so far. Both had common parentage viz., Uthirankotta ( ) and Cherikaniakadan ( ). At IISR, a large number of intercultivar hybrids were produced and they are in different stages of testing. Hybrids tolerant to *Phytophthora*, adapted to high elevation and high yielding lines etc. were located and they are being evaluated. Hybrid lines HP34, 105, 732, 780 and 813 are a few of the short listed ones. Popular land races and improved varieties of black pepper along with their salient features are presented in Tables 7, 8 (Sasikumar *et al*, 1996).

#### BIOTECHNOLOGICAL APPROACHES IN BLACK PEPPER IMPROVEMENT

Genetic variability in cultivated black pepper varieties is very limited for pest and disease tolerance. No resistance exist for the foot rot disease caused by *Phytophthora capsici* and for the slow decline caused mainly by the burrowing nematode, *Radopholus similis*. The advent of R-DNA technique allows the introduction of foreign gene(s) conferring resistance against this disease to established cultivars. Resistant genes from disease resistant species or from other sources, if can be incorporated into cultivated black pepper by genetic engineering technique, will be one of the most effective ways of producing disease resistant varieties. Suitable *in vitro* selection system is a prerequisite in such studies.

Kanamycin sensitivity assay, being a prelude to Agrobacterium mediated genetic transformation, was performed using cotyledons of 'Karimunda' cultivar (Sasikumar and Veluthambi;1994). Callus formation of the cotyledons was completely inhibited at  $50 \text{ mg ml}^{-1}$  and above concentration of kanamycin. Micropropagation as well as callus regeneration

protocols were also standardized for black pepper and related taxa (Mathew & Rao, 1984; Nirmal Babu *et. al.* 1993). Meristem culture, protoplast isolation and its culture were also standardized at IISR.

Crop improvement works in black pepper involving both traditional and biotechnological methods are in progress at IISR, Calicut, Pepper Research Station, Panniyur and at Kerala Agricultural University, Thrissur. These studies will be leading to noval varieties possessing desired characteristics

### CONCLUSION

Unlike in many other crop plants, there is a strong positive relation between yield and quality in black pepper. There are many black pepper cultivars possessing high yield and good quality. A few of the cultivars such as Kottanadan, Kutharavally, Panniyur-1, Panniyur-3, PLD-2 & Sreekara possess high yield along with good quality. Many of the high quality lines identified at IISR, Calicut are being further hybridized with high yielders so as to combine these two traits in a harmonious way.

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Table 1. Species diversity in *Piper* in South India (Western Ghats)

Species	Chromosome No. (2n)
<i>P. argyrophyllum</i> Miq.	52
<i>P. attematum</i> Buch-Ham	52
<i>P. barberi</i> Gamble* En	52
<i>P. betle</i> Lim	26,52,64,78
<i>P. galeatum</i> (Miq.) C.D.C. *	52
<i>P. hymenophyllum</i> Miq.*	104
<i>P. hapnium</i> Ham.* En	52
<i>P. hookeri</i> Miq.* En	104
<i>P. longum</i> Lin.	24,48,52,96
<i>P. mullesua</i> Ham.* En	132
<i>P. nigrum</i> Lim.*	52
<i>P. pseudonigrum</i> Velayudhan*	--
<i>P. schmiditii</i> Hook f.* En	96
<i>P. silentvalleyensis</i> Ravindran & Asokan* En	--
<i>P. sugandhi</i> Ravindra, Babu & Naik * En	52
<i>P. trichostachyon</i> C. D. C.	52
<i>P. wightii</i> Miq* En	52

(\*represents endemic species)      (En = Endangered species)

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**Table 2. Quality composition of important cultivars  
(values on dry weight basis)**

Cultivar	Volatile Oil % (v/w)	Oleoresin % (w/w)	Piperine % (w/w)	Starch % (w/w)
Arikottanadan	4.75	12.90	4.50	24.66
Arakkulamunda	4.75	9.84	4.40	36.18
Balankotta	5.12	9.35	4.26	25.20
Ceylon	3.75	13.50	7.60	15.66
Cheriyakaniakkadan	3.75	9.05	3.95	24.84
Chumala	2.25	5.45	3.30	46.62
Doddigae	2.50	7.10	2.85	36.00
Kalluvally	3.25	8.80	4.24	31.50
Kalluvally (PTB)	0.40	10.90	4.65	29.00
Kalluvally Type-1	3.00	8.44	5.40	20.70
Kaniakkadan	4.75	11.60	6.00	12.42
Kottanadan	2.50	17.80	6.60	23.40
Karimunda	4.00	11.00	4.40	39.60
Karuvilanchy	3.05	9.70	4.30	27.00
Kumbhakodi	4.50	14.90	7.60	18.20
Kuthiravally	4.50	14.90	5.97	14.04
Munda	4.75	7.00	5.60	22.70
Mundi	3.50	7.50	3.60	23.40
Narayakodi	4.00	10.85	5.40	24.50
Nilgiris	5.50	15.50	6.05	23.60
Un named	3.00	7.60	3.60	19.26
Panniyur-1	3.50	9.52	3.60	35.10
Panniyur-2	3.00	8.60	4.00	28.80
Panniyur-3	4.00	8.00	7.40	26.64
Panniyur-4	2.50	7.20	4.56	17.64
Panniyur-5	4.00	6.80	3.60	20.70
Subhakara	2.50	10.80	5.80	32.60
Uthirankotta	4.75	8.65	3.92	28.80
Vally	2.50	6.53	4.90	16.02
Aimpiriyan	2.63	15.70	4.69	-
Udhakara	3.82	8.61	2.36	-
Thommankodi	5.98	13.77	2.77	-
Sreekara	7.00	13.00	5.10	-
Subhakara	6.00	12.40	3.40	-
Panchami	3.40	12.50	4.70	-
Pournami	3.35	13.80	4.10	-

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**Table 3. Categorisation of pepper cultivars on the basis of piperine, oleoresin and essential oils content**

Constituent	Name of the cultivar	Category & level of the constituent
<b>Piperine</b>	Ceylon, Kaniyakkadan, Kottanadan, Kumbhakkodi, Kuthiravally, Munda, Nilgiris, Perumunda, Taliparamba Local, Karimunda.	High > 5.49
	Arikottanadan, Arakulammunda, Balankotta, Cheriakaniakadan, Chumala, Doggigae, Kallu-valy(I), Kalluvaly(II), Kalluvaly(III), Karimunda(I), Karuvilanchy, Mundi, Narayakodi, Pallouta, Panniyur-1, Perumkodi, Shimoga, Sullia, Uthirankotta, Vally, Local (Sagar). Kuthiravally(I), Thommankodi(I), Kalluvaly(IV), Kurimalai, Aimpirian(I), Karimunda(II), Balankotta, Aryanmundi, Padappan, Thirthahally, Karimunda(III), Karimalligeswara, Thommankodi(II), Kodi, Kottanadan, Aimpirian(II), Karimunda(IV), Aimpirian(III), Perambaramunda, Kuthiravally(II).	Medium 5.49-2.59
	Vokkalu, Narayakodi, Kalluvaly(V), Udhakere, Doddale, Kuthiravally(II), Uddakhere(II), Local (Pulpally)	Low < 2.59
<b>Oleoresin</b>	Kottanadan, Kumbhakkodi, Kuthiravally(I), Nilgiris, Aimpirian, Kuthiravally(II), Udhakere, Pulpally, Malabar.	High > 14.62
	Arikottanadan, Arakulammunda, Balankotta, Ceylon, Cheriakaniyakkadan, Kalluvaly(I), Kallu-valy(II), Kalluvaly(III), Kaniyakkadan, Karimunda(I), Karuvilanchy, Narayakodi, Panniyur-1, Perumkodi, TMB-II, Uthirankotta, Thirthahalli, Kurimalai, Karimunda(II), Karimalligeswara, Thommankodi, Doddale, Kodikottanadan, Karimunda(III), Arayanmundi, Aimpirian, Perambaramunda, Vokkalu, Local(Sagar), Narayakodi, Kuthiravally(I), Kalluvaly(IV), Udhakere, Karimunda(IV), Kari-munda(V), Aryanmundi, Padappan.	Medium 14.62-8.38
	Doddigae, Chumala, Munda, Mundi, Patullouta, Perumunda, Shimoga, Sullia, Vally, Karimunda(VI).	Low < 8.38
<b>Essential Oil</b>	Arikottanadan, Arakulammunda, Balankotta, Kaniyakkadan, Kumbhakkodi, Kuthiravally(I)	High > 4.40
	Munda, Nilgiris, Perambaramunda, Kalluvaly(I), Thommankodi, Karimunda(I), Ceylon, Cheriakaniyakkadan, Doddigae, Kalluvaly(II), Kalluvaly(III), Kottanadan, Karimunda(II), Karuvilanchi, Mundi, Narayakodi, Pallouta, Panniyur-1, Perumkodi, Perumunda, Shimoga, Sullia, TMB, Uthirankotta, Vally, Karimunda(III), Kurimalai, Karimunda(IV), Karimalligeswara, Thommankodi, Kodikottanadan, Karimunda(IV), Aimpirian, Kuthiravally(I), Kuthiravally(II), Vokkalu, Local(Sagar), Narayakodi, Kuthiravally(III), Kalluvaly(IV), Udhakere, Kurimalai, Aimpirian, Karimunda(IV), Malabar, Aryanmundi, Kottanadan, Padappan.	Medium 4.40-2.40
	Chumala, Kalluvaly(V), Thirthahalli, Vokkalu, Doddale, Arayanmundi, Uddakhere, Pulpally (Local).	Low < 2.40

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**Table 4. Classification of pepper cultivars (*Piper nigrum*) based on berry size**

Large size (>4.25 mm)	Medium size (3.25-4.25 mm)	Small Size (<3.25 mm)
Panniyur-1 Valiakaniakadan Vadakkan Karuvilanchi	Karimunda Arakulamunda Vattamunda Ottaplackal Kuthiravally Thevanmundi Kaniakadan Neelamundi Balankotta	Kurialmundi Narayakodi

**Table 5. Chemical quality of white (W) and black (B) pepper in a few selected popular cultivars (Expressed as % dry weight)**

Cultivar		Piperine (%)	Oleoresin (%)	Essensial Oil (%)
Panniyur - 1	W	3.60	8.6	2.4
	B	3.72	9.1	3.6
Valliakaniakadan	W	3.50	7.7	2.6
	B	3.60	8.2	4.0
Vadakkan	W	2.29	9.1	2.0
	B	3.90	10.6	3.5
Kuruvilanchy	W	3.15	9.7	3.2
	B	3.16	12.4	4.3
Karimunda	W	2.93	7.8	2.5
	B	3.86	9.3	4.2
Arakulamunda	W	3.47	10.0	2.9
	B	3.82	11.11	3.6
Vattamunda	W	5.85	6.8	2.6
	B	5.94	8.8	3.8
Ottaplackal	W	4.50	7.5	2.3
	B	4.80	10.2	4.6
Kuthiravally	W	3.20	6.3	2.5
	B	5.90	8.9	4.5
Thevanmuddi	W	2.70	6.4	2.2
	B	3.70	8.6	3.1
Kaniakadan	W	4.60	10.3	2.0
	B	6.00	11.6	4.8
Neelamundi	W	2.70	8.3	2.7
	B	3.20	10.6	3.3
Balankotta	W	2.80	9.4	2.7
	B	4.30	10.1	4.0
Kurielmundi	W	3.50	8.5	2.8
	B	3.60	9.6	3.0
Narayakodi	W	4.60	9.0	2.8
	B	4.80	10.9	4.8

W=White Pepper    B=Black Pepper

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**Table 6. Methods of crop improvement in black pepper**

Methods	Genotypes
1) Introduction	Bangka, Balantung, Jambi, Kuching, Lampung (from Indonesia, Malaysia)
2) Clonal selection	Sreekara, Subhakara, Penniyur-4 & PLD-2
3) Selections from germplasm	Pachami, Pournami
4) Progeny selection	Panniyur-2, and Panniyur-5
5) Hybridization & selection	Panniyur-1, Panniyur-3, HP 34, HP 105, Hp732, HP 780, HP 813
6) Interspecific hybridization (for transferring pollu beetle resistance)	<i>P. nigrum</i> x <i>P. attematum</i> <i>P. nigrum</i> x <i>P. barberi</i>
7) Mutation Breeding	---
8) Polyploidy breeding	Tetraploid (Panniyur-1)(4n=104) Produced Natural triploid (Vadakkan)(3n=78 Identified progenis of triploid mother under study. Polyploid lines under field evaluation
9) Tissue culture/ Genetic Engineering	Micropropagation, callus induction and regeneration maristem culture protoplast isolation and culturing etc. standardised Agrobacterium mediated transpormation of black pepper achieved

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**Table 7. Popular land races of black pepper**

Name and Remarks	Yield/vine (kg/fresh)	Dry recovery %	Oleoresin %	Piperine %	Essential Oil %
<b>Almpiriyam.</b> Originally from in Wynad. Performs well in plains and hilly regions: not suitable for shaded areas, late to mature	4 - 5	34 - 35	12 - 13	4 - 5	2.5 - 3.0
<b>Arakulammunda.</b> From Thodupuzha area, early variety	1.5 - 2.0	33	9.8	4.4	4.7
<b>Balankotta.</b> A Malabar cultivar, tolerant to shade. Performs well as mixed crop in arecanut gardens	1 - 3	33	9.3	4.0	5.0
<b>Kalluvally.</b> A Malabar cultivar, hardy in nature	1 - 2	35 - 38	8.4 - 11.8	2.5 - 5.4	3.0
<b>Karimkotta.</b> A common cultivar of Malabar, hardy and tolerant to drought and to some extent tolerant to disease.	2.0	35	12	4.4	3.1
<b>Karimunda.</b> Originally from South Kerala. Now very popular through out Kerala. Tolerant to shade, performs well as a mixed crop.	3 - 5	32 - 38	7 - 13.1	4.4 - 6.2	3.5
<b>Kottanadan.</b> From Nedumangad taluk of Trivandrum district. Performs well in plains and hilly regions upto 700-800m MSL. Widely adapted and high yielding	5	34 - 35	17.8	6.6	2.5
<b>Kurimalai.</b> Popular in Sagar district Karnataka, Performs well as inter crop in coconut and arecanut gardens. Not suitable for Kerala.	2 - 3	33 - 35	12.6	3.37	3.6
<b>Kuthiravally.</b> A cultivar from Central Kerala, now popular in Wynad, Idukki and Cannanore districts. A stable yielder	3	35	15.0	6.0	4.5
<b>Malligesara.</b> A cultivar of Uttara Kannada. Suitable for mixed cropping in arecanut gardens.	2.3	-	-	-	-
<b>Narayakodi.</b> A cultivar of Kottayam district, now common in all pepper growing tracts. Somewhat field tolerant to disease.	1.5 - 2.0	36.0	11.0	5.4	4.0
<b>Neelamundi.</b> Reported to be somewhat field tolerant to foot rot. Suitable for high elevation areas.	2.0	33 - 34	13.9	4.6	3.3
<b>Perambammunda.</b> A cultivar of Malabar resembling Neelamudi. Berries are bold	2.0	35	10.2	2.	2.9
<b>Poonjaranmunda.</b> A variety originally from Poonjar in Kottayam district. Moderate yielder	2.0	35	11.6	4.76	4.7
<b>Valiakanayakkadan.</b> Originally from Central Kerala side. Now almost out of cultivation. Poor yielder	2 - 3	33	9.9	3.5	5.3
<b>Vellanamban.</b> Originally from Central Kerala. Reported to be tolerant to drought	2 - 3	34	9.0	3.4	3.4