Short Communication

Evaluation of exotic banana germplasm for growth and yield attributes under Kerala conditions

P.R. Manju* and P.B. Pushpalatha

Banana Research Station, Kannara, Kerala Agricultural University, Thrissur 680 652, Kerala, India

Received 25 December 2021; received in revised form 30 March 2022; accepted 05 April 2022

Abstract

Introduction and evaluation of exotic banana germplasm was undertaken at Banana Research Station, Kannara, Kerala Agricultural University under the ICAR – AICRP on Fruits. Two exotic cultivars *viz*., Popoulu belonging to the Maia Maoli /Popoulu group of the AAB genome and Kluai Namwa Khom belonging to the Pisang Awak subgroup of the ABB genome were evaluated for their performance under Kerala conditions. Popoulu was compared against the Nendran clones (AAB), Nedunendran and Manjeri Nendran II, while Kluai Namwa Khom was evaluated with local Pisang Awak cultivar Karpooravalli. The investigation showed that both the introductions are promising for cultivation in Kerala. They outperformed their check varieties in terms of bunch weight, yield and other biometric characters. Popoulu can be popularised as a dessert cum cooking variety, highly suitable for the chips industry. Kluai Namwa Khom is a dwarf variety suitable for table purpose and can be recommended in high wind prone areas.

Keywords: Karpooravalli, Kluai Namwa Khom, Nendran, Pisang Awak, Popoulu.

Banana is the fourth most important fruit crop in the world with more than thousand domesticated *Musa* cultivars. The genetic diversity in the crop is high due to multiple origins from different wild hybrids between two ancestral species *viz*., *Musa acuminata* Colla (A genome) and *Musa balbisiana* Colla (B genome). The Indian subcontinent is thought to have been a major centre for hybridization of *acuminata* types with the indigenous *M. balbisiana,* and the region is noted for a wide variety of AAB and ABB cultivars. It is thought that the dispersal of edible bananas outside Asia brought about by humans (Simmonds, 1962) resulted in the development of distinct sub-groups of varieties in different geographic locations. Mutations, affecting traits of economic or horticultural interest, have been selected by farmers over the years and multiplied by vegetative propagation to produce morphotypes. Movement eastwards resulted in the development of a distinct group of AAB bananas known as the Maia Maoli/ Popoulu group which are cultivated throughout the Pacific Islands.

The ABB genomic group comprises of starchy bananas that are used for cooking, dessert and beer production. The ABB cultivars belong to a morphologically diverse group (Daniells et al., 2001) of which the Pisang Awak (ABB) subgroup offers a group of clones which are hardy, suitable to marginal soils, tolerant to low temperature and can be grown in altitudes ranging from 50 to 1,400 m above MSL. These qualities have enabled them to be grown in a wide range of geographic locations (Singh and Uma, 2000), however, many states in India are still thriving on poor yielding local Pisang Awak cultivars for their livelihood. The common Pisang Awak cultivar in South India *viz*.,

*Author for correspondences: Phone: 9446331330, Email: manjupr.nair@gmail.com

Karpooravalli is noted for its tall stature and longer crop duration, which restricts its cultivation on a commercial scale.

Unlike other states in India, Kerala is characterized by a wide range of cultivars of banana, of which nearly 50 per cent is occupied by plantains (FIB, 2019), particularly Nendran. However, the commercial cultivation of Nendran is often challenged by its low inherent yielding ability (Menon et al., 2011) and susceptibility to many pests and diseases (Thippaiah et al., 2010; George et al., 2019). Banana is one of the toughest crops that can be improved through conventional breeding. In this situation, introduction of exotic *Musa* germplasm opens the genetic basket and offers more choice for identification and popularisation of promising varieties.

At Banana Research Station (BRS), Kannara, Kerala Agricultural University, introduction, characterization and evaluation of exotic *Musa* germplasm has been undertaken since 1994, under the aegis of ICAR - All India Coordinated Research Project (AICRP) on Fruits (Menon et al., 2005). 'Popoulu' (accession EC320555, AAB) belonging to the Maia Maoli/Popoulu group and Kluai Namwa Khom (ITC0526, ABB), an exotic Pisang Awak member was obtained from the National Bureau of Plant Genetic Resources (NBPGR), New Delhi, for its characterization and evaluation during 1994 and 2009 respectively. The germplasm was acquired by NBPGR from the erstwhile International Network for Improvement of Banana and Plantain (INIBAP), now known as the *Musa* International Transit Centre (ITC), Leuven, Belgium. Morphological characterization was undertaken using the IPGRI standard descriptors for banana (Menon et al., 2014).The present work was undertaken to evaluate the performance of 'Popoulu' and Kluai Namwa Khom as part of multi-location trial under the ICAR – AICRP (Fruits).

In vitro rooted plantlets of 'Popoulu' obtained from NBPGR were hardened and multiplied in the field at BRS, Kannara. Standard package of practices for banana were followed for raising the crop (KAU, 2016). During 2016 – 2020, the two varieties were field evaluated for two seasons on a Randomized Block Design with 12 replications for growth, yield, quality and reaction to eumusae leaf spot disease. The experimental field was located at 10.53° N latitude and 76.32° E longitude and at an elevation of 58 m above MSL. The station enjoys an annual precipitation of about 2800 mm from both North-East and South-West monsoons. The soil type is laterite with pH ranging from 4.5 – 5.2. Popoulu was evaluated against Nendran (plantain) clones *viz*., Nedunendran (AAB) and Manjeri Nendran II (AAB) as check varieties, while Kluai Namwa Khom was compared with local Pisang Awak cultivar Karpooravalli (ABB) as check.

Growth characters like plant height, pseudostem girth, leaves per plant, suckers per plant and leaf area were recorded at bunching. Leaf area was calculated by multiplying the product of number of leaves, leaf length and width (at the broadest part of the third leaf) by the factor 0.8 (Murray, 1960) and expressed in m^2. Days to shooting was taken as number of days from planting to bunch emergence. Days from bunching to harvest was taken as days to maturity. Crop duration was taken as days from planting to harvest. Observations on bunch characters (bunch weight, hands per bunch, fingers per hand and fingers per bunch) were taken at harvest (full maturity). Middle finger in the top row of the second hand (from the base of the bunch) was designated as the index finger or D finger for studying the finger characters *viz*., finger weight (g), pulp weight (g), finger length (cm) and finger girth (cm). Fruit quality characters like TSS and fruit acidity (%) was also estimated (Ranganna, 1997) after harvest on ripening. Shelf life (yellow) was taken at ambient room temperature from ripening to decay.

Scoring for Eumusae leaf spot incidence

The disease severity was assessed at bunching stage using Gauhl's modification of Stover's severity

scoring system score chart (Carlier et al., 2002). The per cent disease severity was calculated using the formula: Per cent disease severity (PDS) = [Σnb/ (N - 1) T] x 100 where, n= number of leaves in each grade, b= grade, N=Number of grade used in the scale, T= total number of leaves. Statistical analysis for each parameter was done as per Panse and Sukhatme (1967).

Plant height, pseudostem girth, leaves per plant, suckers per plant and leaf area recorded at bunching are presented in Table 1. In AAB group, Popoulu was on par with the local checks for growth characters like pseudostem girth and suckers per plant. Manjeri Nendran II recorded more plant height (3.11 m) compared to the other two, while, more leaves per plant (10.12) and leaf area (12.49 m^2) were observed in Popoulu. Menon et. al. (2014) observed that Popoulu is a variety which is comparable to 'Nendran' in terms of plant height and pseudostem girth, but has more leaves per plant. Unlike Nendran, Popoulu is not vulnerable to strong winds and hence no propping is required. The introduced variety Kluai Namwa Khom (ABB Pisang awak subgroup) was shorter than Karpooravalli by almost 1 metre with a plant height of 2.38 m along with more leaves per plant (13.39) and leaf area (16.00 m^2). Both varieties were similar in growth characters like pseudostem girth and suckers per plant. A similar study conducted by Uma et al. (2005) confirms the performance of another Pisang awak cultivar *viz*., NRCB Selection 001 to be tolerant to high wind velocity due to its medium plant height, higher pseudostem girth and robust nature when compared to other cultivated types in the same group. Kluai Namwa Khom can also be recommended as tolerant to strong winds due to its dwarf stature and as such does not require propping.

In banana, hands per bunch, fingers per bunch, finger length and bunch weight contribute to the total yield components. Bunch weight exhibited significant differences among the test cultivars evaluated. Days to bunching, days to harvest and crop duration varied among the varieties (Table 2). Nedunendran was the earliest in bunching (221.19 days) which was significantly on par with Popoulu (244.20 days), while Manjeri Nendran II took the longest duration (272.29 days) to bunch. Days to maturity was least for Popoulu (63.79 days) which

Table 1. Vegetative characters of banana varieties at bunching

Treatment	Plant height (m)	Pseudostem girth (cm)	Leaves/ plant	Suckers/ plant	Leaf Area (m^2)
Popoulu	3.02	58.49	10.12	4.62	12.49
Manjeri Nendran II	3.11	52.32	9.58	4.72	11.18
Nedunendran	3.03	50.43	8.50	4.82	6.76
$SE_{m\pm}$	0.85	1.11	0.40	0.17	0.30
CD (P=0.05)	0.06	NS	0.92	NS	2.26
Kluai Namwa Khom	2.38	69.65	13.39	4.36	16.00
Karpooravalli	3.46	64.00	11.15	5.24	12.67
SEm±	0.01	1.03	0.34	0.24	0.08
CD (P=0.05)	0.95	NS	0.96	NS	1.46

*Table 2.*Yield, duration and B:C ratio of banana varieties

Treatment	Bunch weight (kg/plant)	Yield(t/ha)	Days to bunching	Days to maturity	Crop duration	B : C ratio
Popoulu	16.01	39.89	244.20	63.79	307.99	2.94
Manjeri Nendran II	13.01	32.52	272.29	87.09	359.38	2.52
Nedunendran	10.90	27.24	221.19	89.52	310.71	1.79
SEm±	0.24	0.62	4.78	0.78	3.31	-
CD (P=0.05)	1.77	4.61	35.60	5.79	24.68	-
Kluai Namwa Khom	20.64	51.60	276.98	95.96	372.94	2.73
Karpooravalli	17.02	42.54	331.76	90.36	422.12	2.00
SEm±	0.07	0.17	0.68	0.41	1.09	-
CD (P=0.05)	1.21	2.99	12.26	NS	19.57	-

Plate 1.Popoulu bunch

Plate 2. Popoulu hand

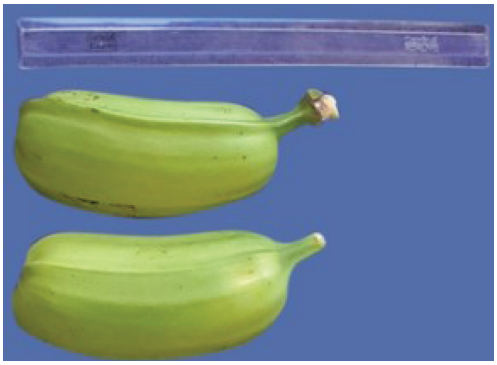

Plate 3. Popoulu fingers

Plate 4. Manjeri Nendran II bunch

Plate 5. ManjeriNendran II hand

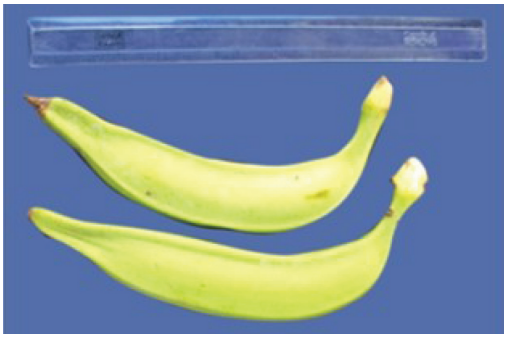

Plate 6. ManjeriNendranIIfingers

Plate 7. Kluai Namwa Khom bunch

was 23 to 25 days earlier than Manjeri Nendran and Nendran respectively. Both the plantains, Manjeri Nendran II as well as Nedunendran were statistically similar for days to bunching. Popoulu had shorter crop duration which was on par with Nedunendran, while Manjeri Nendran II took 359.38 days from planting to harvest. Considering yield characters, Popoulu recorded 16.01 kg bunch weight per plant and a yield of 39.89 t/ha, followed by Manjeri Nendran II and Nedunendran (Plates 1 and 4). This implies an additional yield of 23% from Popoulu when compared to the next best cultivar in the state *viz*., Manjeri Nendran II. Menon et al. (2014) reported a crop duration of 298 days in 'Popoulu' which was the shortest when compared to all other

Plate 8. Karpooravalli bunch

tested checks (311 to 358 days) belonging to the AAB genome.

Among the Pisang Awak cultivars, Kluai Namwa Khom registered the least duration for bunching (276.998 days) as well as for harvesting (372.94 days). The introduced variety was early to harvest by as much as 50 days than the local cultivar Karpooravalli, which had a crop duration of 422.12 days. Irrespective of days to bunching, there was no significant difference between them for days to maturity. Crop duration is an important trait governed by genotypic, phenotypic and environmental factors along with their interactions. In the Indian production system, Pisang Awak cultivars are maintained for one crop and two ratoons, which are expected to be completed by three years. Any variety with a longer crop duration fails to fit into the three year production cycle (Uma et al., 2005), which is a significant factor that restricts the cultivation of Karpooravalli on a commercial scale and offers more scope for the

introduced variety. Namwa Khom also outperformed Karpooravalli with a bunch weight and yield of 20.64 kg per plant and 51.60 t/ha respectively (Plates 7 and 8). An additional 21 per cent yield was obtained from the introduced variety in comparison with its check.

Leaf area is a critical factor controlling efficiency of photosynthesis which further contributes to increased yield. Light interception by the leaf surface has been reported to be one of the important factors governing the ultimate yield in banana and plantains. In the present investigation, leaves per plant and leaf area were higher in Popoulu as well as in Namwa Khom which contributed to a greater extent for increased yields. B:C ratio was also recorded more for Popoulu (2.94) and Kluai Namwa Khom (2.73) in their respective groups. Nendran ecotypes *viz*., Myndoli, Mettupalayam Nendran and Big Ebanga which showed higher leaf area also recorded higher yield (Joseph and Simi, 2020).

The increased yield observed in Popoulu was contributed by more hands per bunch (6.60) and finger weight (212.04 g) shown by the variety (Table 3, Plates 2 and 5). There was no significant difference among the varieties for fingers per bunch. Finger length observed was higher in Manjeri Nendran II and Nedunendran. Pulp: peel ratio was also more for Popoulu (3.17) which is a desirable character in fruit crops. Joseph and Simi (2020) observed a variation in pulp/ peel ratio from 2.90 (Attunendran) to 3.85 (Chengalikodan) while studying nendran clones of Kerala. Traits like finger weight, finger girth and pulp to peel ratio was found to be high in Popoulu and this uniqueness of the variety makes it suitable for processing industry for the preparation of chips. Popoulu has a characteristic fruit shape, where the fruits are straight with a blunt apex (Plate3.), while its girth and weight were significantly higher than the plantains (Plate 6.). In India, Nendran is the commercial variety currently being grown and favored by the consumers as well as by processors for the preparation of chips. Studies on alternate varieties suitable for chips preparation has led to identification of Popoulu, which is not only high yielding but also suitable for chips. Kumara et al. (2020) recorded a chips recovery as high as 40.45% in Popoulu with an overall acceptability score of 8.07, when compared to nendran (7.56). Menon et al. (2014) observed a striking resemblance of ripe fruit pulp of Popoulu with Nendran, and confirms the suitability of the variety not only for dessert, but also for cooking and for chips.

Hands per bunch, fingers per hand and fingers per bunch did not vary between Kluai Namwa Khom and Karpooravalli. The higher bunch weight in Kluai Namwa Khom was attributed to its increased finger weight, finger length and finger girth. Pulp : peel ratio was non-significant among the Pisang Awak cultivars. In general, thin skinned cultivars like Silk (Malbhog), Ney Poovan (Elakki Bale) and Pisang Awak members exhibit a ratio more than 2.5 (Uma et al., 2005). Kluai Namwa is one of the most common dessert banana cultivar in Thailand, which has been processed traditionally to many Thai

Table 3. Fruit characters of banana varieties at harvest

Treatment	Hands per bunch	Fingers per hand	Fingers per bunch	Finger weight (g)	Pulp weight(g)	Pulp : peel ratio	Finger length (cm)	Finger girth (cm)
Popoulu	6.60	7.01	63.16	212.04	161.23	3.17	16.92	19.83
Manjeri Nendran II	5.84	10.59	61.65	172.26	127.89	2.88	22.98	14.32
Nedunendran	5.46	10.01	54.73	162.82	117.31	2.58	21.89	12.92
SEm±	0.02	0.08	1.89	2.86	2.07	0.02	0.16	0.63
CD (P=0.05)	0.12	0.57	NS	21.28	15.44	0.24	1.16	4.68
Kluai Namwa Khom	10.83	15.25	175.29	124.39	83.41	2.54	13.75	13.03
Karpooravalli	10.27	15.40	164.40	76.30	49.37	2.32	11.02	10.98
SEm±	0.07	0.56	2.35	0.88	1.57	0.01	0.11	0.11
CD (P=0.05)	NS	NS	NS	15.88	28.14	NS	1.91	1.91

Table 4. Quality characters of banana varieties at harvest

Treatment	TSS (°B)	Fruit acidity (%)	Shelf life (days)
Popoulu	26.32	0.29	4.41
Manjeri Nendran II	26.24	0.28	4.91
Nedunendran	27.01	0.31	4.67
SEm±	0.48	0.01	0.20
CD (P=0.05)	NS	NS	NS
Kluai Namwa Khom	28.31	0.34	4.86
Karpooravalli	28.48	0.35	4.80
SEm±	0.41	0.02	0.13
CD (P=0.05)	NS	NS	NS

Table 5. Reaction to Eumusae leaf spot among banana varieties

Treatment	PDI
Popoulu	12.63
Manjeri Nendran II	13.18
Nedunendran	23.18
SEm±	0.34
CD (P=0.05)	2.50
Kluai Namwa Khom	15.24
Karpooravalli	18.47
SEm±	1.46
CD (P=0.05)	NS

desserts and even to banana fig (Siriboon and Banlusilp, 2004).

Edible fruit quality in a broad sense depends on TSS, acidity and their blend. Fruit quality characters like TSS, acidity and shelf life esimated shows that there was no variation among the varieties for these parameters (Table 4).

Eumusae leaf spot disease complex caused by *Mycosphaerella* spp. is a serious constraint to banana cultivation as it destroys the functional photosynthetic leaf area and causes considerable reduction in yield (George et al., 2019). Eumusae leaf spot disease caused by *M. eumusae* destroys the photosynthetic green leaf tissue through the development of necrotic leaf lesions and results in a yield loss of 11 to 80 per cent (Shanthiyaa et al., 2013). Thus, this disease limits the cultivation of the popular but susceptible cultivars like Nendran. The geographical position and climatic conditions prevailing in the state of Kerala are also highly favourable for the development of this fungal disease throughout the year. Again, in the wake of the recent ban of many recommended plant protection chemicals, identification of resistant / tolerant varieties is essential. In the present study, the reaction of test varieties to eumusae leaf spot revealed that Popoulu and Manjeri Nendran II are tolerant (PDI 10.1 – 20.0) to the disease with a PDI value of 12.63 and 13.18 respectively (Table 5). Nedunendran recorded a PDI of 23.18 which is in the highly susceptible category (PDI 20.1 – 30.0). Both Kluai Namwa Khom and its check Karpooravalli remained on par (PDI 15.24 and 18.47 respectively) and falls in the tolerant range.Uma et al. (2005) while evaluating Pisang Awak cultivars observed a disease severity of 9.03 - 12.17 for eumusae leaf spot.

The present investigation identified two potential exotic banana cultivars suitable for cultivation under the agroclimatic conditions of Kerala. Popoulu can be popularised as a potential dessert cum cooking variety, while its potential in processing industry particularly for chips preparation is immense. It has great potential for popularization in Kerala as a profitable cultivar to complement 'Nendran' ecotypes. Preliminary studies at Banana Research Station, Kannara shows that the raw banana powder from Popoulu can find application in the preparation of several powder based products as well. Kluai Namwa Khom, a dwarf variety with a shorter crop duration than local cultivar Karpooravalli, is suitable for dessert purpose and for the preparation of banana fig. Both Popoulu and Kluai Namwa Khom can be cultivated without giving any propping, saving approximately 15% of the total production cost of banana. While 'Popoulu' displayed slight tolerance to Sigatoka leaf spot in comparison to Nendran, the variety has shown susceptibility to rhizome rot and fruit fly. Similarly, Kluai Namwa Khom and Pisang Awak members in general are susceptible to *Fusarium* wilt. Hence necessary practices for the management of these pests and diseases should be recommended during the cultivation of these varieties.

Acknowledgement

The authors are thankful to ICAR-AICRP (Fruits) and Kerala Agricultural University for providing the facilities and supporting the work.

References

Carlier, J., de Waele, D. and Escalent, J.V. 2002. Global evaluation of *Musa* germplasm for resistance to *Fusarium* wilt, *Mycosphaerella* leaf spot diseases and nematodes. INIBAP Technical Guidelines 6, INIBAP, Montpellier, France, 68p.

Daniells,J., Jenny, C., Karamura, D.A. and Tomekpe, K. 2001. Musalogue: a catalogue of *Musa* germplasm: diversity in the genus *Musa*. International Network for the Improvement of Banana and Plantain (INIBAP), Montpellier, France, 207p.

FIB (Farm Information Bureau). 2019. Farm Guide 2019, Farm Information Bureau, Agriculture Development and Farmer's Welfare Department, Government of Kerala, 294p.

George, M., Cherian, A.K. and Louis, V. 2019. In vivo efficacy of new molecules of fungicides against Eumusae leaf spot disease of French plantain cultivar Nendran (*Musa* AAB). J. Trop. Agric., 57(2): 132–139.

Joseph, A.V. and Simi S. 2020. Evaluation of ecotypes of banana (*Musa* AAB plantain subgroup). J. Trop. Agric., 58(1): 112-118.

KAU [Kerala Agricultural University]. 2016. Package of practices recommendations: crops (14th Ed.). Kerala Agricultural University, Vellanikkara, Thrissur, Kerala, 360p.

Kumara, T.K.N., Kavitha, C., Jeyakumar, P., Balakrishnan, S. and Soorianathasundaram, K. 2020. Popoulu : A promising plantain could strengthen the banana chips industry in India. Asian J. Dairy Food Res., 39(4): 338-343.

Menon, R, Agrawal, A. and Reddy, B.M.C. 2005. Status of introduced *Musa* germplasm at Banana Research Station, Kannara. Indian J. Plant Genet. Resour. 18: 81-83.

Menon, R., Cherian, A., Suma, A., Mathew, P., Nair, S., and Aipe, K.C. 2011. Developing resistant banana and plantain cultivars through conventional breeding techniques. Acta Hort. 897 :207-213.

Menon, R., Nair, S., Suma, A., Manju, P.R., Cherian, A. K., Patil P. and Agrawal, A. 2014. Introduction, evaluation and adoption of an exotic banana (*Musa* AAB cv. 'Popoulu') (EC 320555) to Kerala, India. Indian J. Pl. Genet. Resour., 27(3): 298-302.

Murray, D.B. 1960. The effect of deficiencies of the major nutrients on growth and leaf analysis of banana. Trop. Agric., 37: 97-106.

Panse, V.G. and Sukhatme, P.V. 1967. Statistical methods for agricultural workers. Indian Council of Agricultural Research, New Delhi, 347p.

Ranganna, S. 1997. Handbook of Analysis and Quality Control for Fruits and Vegetable Products (2nd Ed.). Tata McGraw Hill Publishing Company Limited, New Delhi, 1112p.

Shanthiyaa, V., Karthikeyan, G., Raguchander, T., and Prabakar, K. 2013. Prevalence of banana yellow sigatoka disease caused by *Mycosphaerella* sp. in Tamil Nadu. J. Mycol. Plant Pathol., 43(4): 414-418.

Simmonds, N.W. 1962. The classification and nomenclature of the bananas and potatoes: some implications. Proc. Linn. Soc. Lond. 173:111–113.

Singh, H.P. and Uma, S. 2000. Genetic diversity of banana in India. In: Singh, H.P. and Chadha, K.L. (eds), The Proceedings of the Conference on Challenges for Banana Production and Utilization in 21st Century. pp. 136–156.

Siriboon, N. and Banlusilp, P. 2004. A study on the ripening process of 'Namwa' Banana. AU J. tech. 7(4): 159-164.

Thippaiah, M., Kumar, C.T.A., Shivaraju, C. and Chakravarthy, K. 2010. Incidence of banana pseudostem weevil *Odoiporus longicollis* (Olivier) in south Karnataka. Pest Manage. Hortic. Ecsyst. 16(1): 50-53.

Uma, S., Sathiamoorthy, S., Saraswathi, M.S., Durai, P., Sharma, H.O. and Agrawal, A. 2005. Evaluation and utilization of introduced *Musa* germplasm in India. Indian J. Pl. Genet. Resour. 18(1): 79-81.