Sl.No. 1

Int.J.Curr.Microbiol.App.Sci (2019) *8*(2): 2539-2550

International Journal of Current Microbiology and Applied Sciences
***ISSN: 2319-7706* Volume 8 Number 02 (2019)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2019.802.296

Molecular Cloning and Characterization of Coat Protein Gene of *Banana bract mosaic virus* Affecting Banana cv. Mysore Poovan (Aab)

G. Darshan[1], C.K. Anitha[2]*, S. Manjesh[1] and P.S. Abida[3]

[1]*Centre for Plant Biotechnology and Molecular Biology, College of Horticulture, Kerala Agricultural University, Thrissur, India*
[2]*Department of Plant Pathology, College of Horticulture, Kerala Agricultural University, Thrissur, India*
[3]*Department of Plant Breeding and Genetics, Regional Agricultural Research Station, Pattambi, Kerala, India*

**Corresponding author*

Keywords

Banana bract mosaic virus, Coat Protein gene, Mysore Poovan, Cloning, ELI

Article Info

Accepted:
15 January 2019
Available Online:
10 February 2019

A B S T R A C T

Banana bract mosaic disease (BBrMD) is one of the most important viral diseases of banana which leads to a yield reduction. We have identified *banana bract mosaic virus* (BBrMV) in banana plants growing in the regions of southern India based on symptomatology, sequence homology, and Serodiagnostic assays. The viral sequence encoding the coat protein was specifically amplified by RT-PCR (Reverse Transcriptase – Polymerase chain reaction) using specific primers bordering the Coat Protein (CP) gene. The unique amplified product thus obtained was cloned into the pGEM-T vector and the authenticity of the cloned gene verified by colony PCR. The nucleotide sequences and the deduced amino acid sequences were compared with the other BBrMV isolates and found to be identical at both the nucleotide and amino acid sequence level of other isolates with 99 to 96 per cent and 95 to 83 per cent respectively. The phylogenetic analysis by the alignment of CP gene sequences of selected 22 isolates also revealed that the present isolate was more similar to KER2 (Kasaragod) isolate. The recombinant clones developed in the present study could be applied in serodiagnosis and genetic engineering. This could be also used as disease diagnostic probes for more sensitive molecular diagnostic techniques like Nucleic acid spot hybridization.

Introduction

Banana (*Musa* spp.), identified as a 'tropical treasure' is the most remunerative fruit crop which plays a pivotal role in the income security of farmers. The crop is adaptable to diverse environmental condition, could be cultivated throughout the year and suited for homesteads as well as an inter-crop. Banana is vulnerable to a number of pests and diseases which limit its production and productivity (Singh *et al.*, 2011). Among various diseases, the viral diseases caused by *Banana bunchy top virus* (BBTV), *Cucumber*

Journal of Tropical Agriculture 57 (1): 35-39, 2019

Evaluation of clones of banana *Musa* spp. 'Rasthali'(AAB group)

K. Dhanyasree[1], A. Sobhana[2]*, A. Suma[1] and P. B. Pushpalatha[2]

[1] *College of Horticulture, Kerala Agricultural University, Vellanikkara, Thrissur 680 656, Kerala, India.*

[2] *Banana Research Station, Kannara, Kerala Agricultural University, Thrissur 680 656, Kerala, India*

Received 07 August 2018; received in revised form 20 April 2019; accepted 25 April 2019

Abstract

Seven Rasthali clones were evaluated at BRS, Kannara from May 2017 to July 2018 with the objective to characterize the various clones of Rasthali with respect to clonal characteristics, biometric characters, yield potential and fruit quality. Among the clones, Venneer Poovan recorded highest plant height (335.42cm), plant girth (60.18cm), highest total leaf area per plant (12.26m^2) and higher crop duration (434.92 days). Highest bunch weight per plant, number of hands per bunch and number of fingers per hand were recorded in Venneer Poovan, Valiya Poovan and Marthaman. Maximum fruit weight was recorded in Valiya Poovan (92.60g). Quality parameters like TSS, total sugars and sugar - acid ratio were higher in Marthaman. Percentage of disease incidence was higher in Cheriya Poovan and lowest in Marthaman. Based on yield, quality parameters and disease resistance, Marthaman was found to be the best.

Key words: Clonal variation, Growth and yield attributes, Quality, Rasthali.

Introduction

Banana is one of the most important fruit crops grown in our country. India is the largest producer of banana, contributing 17.8 per cent of the global production (FAO, 2016). The crop is grown in an area of 8,58,000 ha with an annual production of 2,91,63,000 MT and productivity of 33.98 t/ha (AGRISTAT, 2017) in India. Bananas and plantains are deeply linked with the traditional culture of Kerala and the state is known for having one of the largest biodiversity of *Musa* spp. More than ten varieties are grown in the state and many of them are under domestic cultivation, of which, Rasthali (AAB group) is one among the choicest banana cultivars for table purpose. The vast difference in agro climatic conditions under which the variety is grown is likely to generate many clones. Therefore, the cultivar grown in different parts of Kerala exhibits variation in both vegetative and reproductive characters. Considering the yield potential and local preferences, farmers select and cultivate definite types, which perform better in that region. But many cultivar types cannot be easily identified if they are closely related to a particular cultivar. However, there are no reports about a particular Rasthali clone with good yield and fruit quality along with resistance to Panama wilt. Hence, the present investigation was undertaken to evaluate Rasthali clones and identify desirable clones for cultivation.

Materials and Methods

The present study was carried out in Banana Research Station, Kannara, Thrissur during 2017-18. A total of seven Rasthali clones identified from Thrissur, Palakkad and Ernakulam districts were planted and maintained at BRS, Kannara. The seven clones of Rasthali banana were planted in Randomized Block Design (RBD) with three replications as per Panse and Sukhatme (1985) at a spacing of 2.1m x 2.1m with four observational plants per replication. Cultural practices as per the Package of Practice Recommendations of Kerala Agricultural University were followed (KAU,

*Author for Correspondence: Phone: 9446041607, Email: sobhana.a@kau.in

Biocatalysis and Agricultural Biotechnology 17 (2019) 60–81

Contents lists available at ScienceDirect

Biocatalysis and Agricultural Biotechnology

journal homepage: www.elsevier.com/locate/bab

Variability of *Pectobacterium carotovorum* causing rhizome rot in banana

G. Geethu Gokul[a], Vimi Louis[b,*], P.M. Namitha[b], Deepu Mathew[a], D. Girija[c], M.R. Shylaja[a], P.S. Abida[d]

[a] Centre for Plant Biotechnology and Molecular Biology, Kerala Agricultural University, Thrissur, Kerala 680656, India
[b] Banana Research Station, Kerala Agricultural University, Kannara, Thrissur, Kerala 680 652, India
[c] Department of Agricultural Microbiology, College of Horticulture, Kerala Agricultural University, Thrissur, Kerala 680 656, India
[d] Regional Agricultural Research Station, Kerala Agricultural University, Pattambi, Kerala 679 306, India

ARTICLE INFO

Keywords:
16S rDNA
Molecular characterization
Musa
Pectobaterium carotovorum
Rhizome rot

ABSTRACT

The rhizome rot or tip over is a major and emerging disease of banana, causing substantial economic losses. Common cultivars such as Grand Naine, Rasthali and Nendran are highly susceptible to this disease caused by different *Pectobacterium* species. Understanding the disease etiology and pathogen variability are essential in management programs. Bacterium *Pectobacterium carotovorum* was isolated from infected rhizomes from 18 locations of Kerala and Tamil Nadu states of India. Pathogenicity of all isolates were confirmed by *in vitro* inoculation in rhizome bits and *in vivo* inoculation in rhizomes of three months old plants and pseudostems of two months old tissue cultured plants of cv. Nendran. Isolates were characterized by cultural, morphological, biochemical, physiological and molecular methods. Cultural characterization was carried out on Nutrient agar (NA), Yeast Extract Glucose Calcium Carbonate (YGC), Logan's medium and Nutrient broth. Morphological characterization was carried out by Gram staining, capsule staining and flagellar staining. Biochemical characterization was done through potato and carrot soft rot test, intrinsic antibiotic resistance, growth of bacteria in three and four per cent NaCl and growth of bacteria in CVP medium. Physiological characterization was carried out by growing the bacterium at different temperatures and pH. Based on these results, 18 isolates were allocated to six groups.

16S rDNA regions of representative isolates of each group have been PCR amplified and the 1.5 kb amplicons were sequenced. Homology and phylogeny analyses had shown that all the groups belong to *Pectobacterium carotovorum*, and two subspecies *carotovorum* and *brasiliense* were identified.

1. Introduction

Banana or plantain (*Musa* sp.) known as 'Apple of Paradise' is one among the ancient fruits known to humankind. Recently, rhizome rot has emerged as a major disease, especially in southern states of India (Usha, 2003; Snehalatharani and Khan, 2010; Nagaraj et al., 2012). Popular banana cultivars Grand Naine, Nendran and Rastali are susceptible to this disease. Symptoms of the disease include massive soft rot accompanied by disagreeable foul smelling rot of the rhizome and internal decay of the pseudostem as the infection spread upward. Infected plants show stunted growth, water soaked appearance on the leaf base, yellowing of leaf and finally toppling over of the plant (Nagaraj et al., 2012).

Different *Erwinia* species (syn. *Pectobacterium*) cause rhizome rot in banana (Kwon et al., 2000). Usha (2003) reported that in Kerala state of India, *Pectobacterium carotovorum* is the pathogen causing rhizome rot in banana. This study reveals the extent of variability and the subspecies of this pathogen present in humid tropics of India, through cultural, morphological, biochemical, physiological and molecular methods.

2. Materials and methods

2.1. Development of bacterial pure cultures

Infected rhizome samples at the initial stage of rotting (10% rotting) were collected from 18 banana fields from Kerala and Tamil Nadu states of India. Type of soil varied between sandy loam to laterite and the disease was observed mainly under conditions of high soil moisture. Samples were collected in sterile polythene bags and brought to the laboratory for pathogen isolation (Fig. 1).

Rhizomes have been washed, cleaned thoroughly and small rhizome

* Corresponding author.
E-mail address: vimi.louis@kau.in (V. Louis).

https://doi.org/10.1016/j.bcab.2018.11.001
Received 10 July 2018; Received in revised form 20 October 2018; Accepted 5 November 2018
Available online 06 November 2018
1878-8181/

Sl. No. 4

Electronic Journal of Plant Breeding, 10 (1): 238 – 247 (Mar 2019) DOI: 10.5958/0975-928X.2019.00028.0
ISSN 0975-928X

Research Article

Growth inhibition as a viable technique to enhance the storage of synthetic seeds of cocoa (*Theobroma cocoa* L.)

K. Shiran[1], A.V. Santhoshkumar[2*], J. Minimol[3] and Jiji Joseph[4]
[1]Scientist (Agroforestry), CAZRI, Jodhpur
[2]Professor (Forest Biology & Tree Breeding) Kerala Agricultural University
[3]Associate Professor (Plant Breeding & Genetics), Kerala Agricultural University
[4]Professor (Plant Breeding & Genetics), Kerala Agricultural University
* **E-Mail:** santhoshkumar.av@kau.in

(Received: 24 Jul 2018; Revised: 18 Jan 2019; Accepted: 8 Feb 2019)

Abstract
Study was conducted to enhance storage life of cocoa (*Theobroma cocoa* L.) seeds through encapsulation and germination inhibition at College of Forestry, Kerala, India. The extracted embryonic axes of the seeds were encapsulated with calcium alginate and kept under different storage media alone as well as in combination with osmolytes under varying levels of relative humidity. Embryonic axes with quarter potion of cotyledon were ideal for preparation of synthetic seeds. Among different storage media, greater longevity and viability were observed in ½ MS media while least longevity was observed in dry cotton. Maximum longevity of 70 days was observed in synthetic seeds stored in cotton with 250 mM sorbitol. Longevity was less than 10 days in dry cotton due to absence of moisture content. The incorporation of MS media in the encapsulation reduced the longevity of synthetic seeds. In addition, MS media was found to reduce the activity of inhibitor. Addition sobitol (250 mM; 500 mM) in the encapsulation media enhanced longevity to 65 days. Duration of desiccation was positively correlated with seed longevity. Synthetic seeds stored with wet cotton and 250 mM sorbitol for 55 days and transferred to wet cotton for germination had longevity of 89 days with 80% germination. The results of present study indicate that it is possible to enhance the storage life of cocoa seeds from two weeks to three months by encapsulation and altering storage environment.

Keywords
Cocoa, Synthetic seeds, Recalcitrant seed, Seed longevity

Introduction

Cocoa (*Theobroma cacao* L.), an evergreen tree native to Amazon basin, is widely domesticated and grown in plantation and agroforestry programmes in the tropics for its beans. Recalcitrant nature of the seed is a limiting factor in plantation establishment of cocoa. Usually, the viability of cocoa seeds lasts only for a maximum of two weeks (Sudhakara *et al.*,2000). Several techniques have been tried to extend the longevity of cocoa seeds, including maintaining them in the pod or treating the extracted seeds with fungicides, osmotic, respiration inhibitors and hormones (Figueiredo, 1986). Partial drying of the seed for a few hours, treating with fungicide followed by sealed storage in thin polythene bags at low temperature at15°C could extend the storage life in cacao (King and Roberts, 1980). Storing cocoa seeds in pods coated with paraffin wax doubled the storage life of seeds to 28 days (Friend, 1964). Storage was further enhanced by leaving an unwaxed central band on the pod which presumably permitted respiratory exchange with minimal water loss. Isolated embryonic axes of cocoa could not survive either freezing or desiccation (Pence, 1991). Subsequently, Pence (1992) found that although cocoa embryos themselves do not survive liquid nitrogen treatment some of their cells do, allowing the technique to be used to regenerate somatic embryos with average survival of 38%.

Recalcitrant nature of seeds is supposed to be due to seed coat and storage tissue which could be overcome by the production of synthetic seeds from excised embryos (King and Roberts, 1980). Synthetic seed comprises of an embryo separated from its accessory structures and encapsulated in a hydrated gel capsule, which will permit the natural development of the embryo (Murashige,1997).Synthetic seed technology was found to be effective in increasing longevity of seeds of cocoa up to three weeks (Sudhakara *et al.*,2000). They developed synthetic seeds having bead size of 4.5 mm to 5 mm from excised embryos of mature seeds (approx. 120 days old pods) and encapsulating in a medium

Indian Journal of Plant Genetic Resources
Year : 2018, Volume : 31, Issue : 2
First page : **(178)** Last page : **(184)**
Print ISSN : 0971-8184. Online ISSN : 0976-1926.
Article DOI : 10.5958/0976-1926.2018.00021.9

Sl. No. 6

Consumer preference: Crucial in determining the grain Type-Richness in rice varieties grown across Kerala, India

Suma A[1,*], Francies RM[2], Radhakrishnan VV[2], Beena C[2], Bisht IS[3]

[1]ICAR-National Bureau of Plant Genetic Resources, Regional Station, Vellanikkara, KAU, P.O, Thrissur-680656, Kerala, India

[2]College of Horticulture, Kerala Agricultural University, Vellanikkara, KAU.P.O, Thrissur-680656, Kerala, India

[3]ICAR-National Bureau of Plant Genetic Resources, Regional Station, Bhowali-263132, Nainital, Uttarakhand, India

***Author for Correspondence:** Email-sumaagri@gmail.com

Online published on 6 September, 2018.

Abstract

Popularity, preference and acceptability of a variety are dependent on grain qualities among other aspects. With emphasis on development of rice varieties with consumer acceptable grain qualities is gaining momentum, an attempt was made to assess the variability in grain characteristics of traditional as well as high yielding rice varieties grown across Kerala. The analysis of variance revealed existence of highly signifi cant differences among the genotypes for all the grain characteristics studied. Low influence of environment on trait expression was evident from narrow difference observed between phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV). The results of cluster analysis and Principal Component Analysis (PCA) proved that the varieties were diverse in their grain characteristics. The cluster analysis indicated remarkable homogeneity among the traditional rice varieties for the grain characteristics evaluated. The cooking parameters were best expressed by the short-grain high yielding variety Varsha.

Biological Journal of the Linnean Society, 2018, **123**, 311–320. With 4 figures.

Hiding in plain sight: leaf beetles (Chrysomelidae: Galerucinae) use feeding damage as a masquerade decoy

ALEXANDER S. KONSTANTINOV[1], K. D. PRATHAPAN[2] AND FREDRIC V. VENCL[1,3,4]*

[1]*Systematic Entomology Laboratory, Agricultural Research Service, Unites States Department of Agriculture c/o National Museum of Natural History, Smithsonian Institution, Washington, DC 20013, USA*
[2]*Department of Entomology, Kerala Agricultural University, Vellayani P.O., Trivandrum-695 522, Kerala, India*
[3]*Ecology and Evolution, Stony Brook University, Stony Brook, NY 11794–5245, USA*
[4]*National Museum of Natural History, Smithsonian Institution, Washington, DC 20013, USA*

Received 27 October 2017; revised 15 November 2017; accepted for publication 16 November 2017

We report on a unique variant of the masquerade strategy, wherein small herbivorous leaf beetles (Chrysomelidae: Galerucinae) have recurrently evolved a close resemblance to innocuous, unprofitable decoy objects of their own manufacture, i.e. their own feeding damage. Our study is based on a worldwide sample of 119 species of leaf beetles in the subfamily Galerucinae. Most species (115) are members of the tribe Alticini, the flea beetles *s.s.*, known for their remarkably swift jumping ability and astonishing diversity. Masquerading beetles are small, ranging in length from 1.4 to 4.2 mm, monochromatically light or dark, and lack contrasting patterns or warning colours. Although many species make shallow, light colored trenches, 53% of the adult feeding damage consists of closely spaced, oval to elongate holes that completely penetrate the host leaf, which gives it a pitted, stippled appearance. Body area was correlated with feeding hole area. Hole area increases by 0.60 mm^2 for each square millimetre of beetle area. Log–linear modelling showed that beetle body colour was darker when damage was darker and lighter when damage was lighter and when host leaves were broad as opposed to narrow and were oriented horizontally as opposed to vertically. We discuss why masquerade is not a response to induced host plant defences. These findings support the hypothesis that intense selection by visually orienting predators, such as insectivorous birds, has driven small leaf beetles to evolve bodies more closely to resemble their feeding damage and evolve their feeding habits to produce damage that resembles their own bodies.

ADDITIONAL KEYWORDS: camouflage – defence – herbivory – mimicry – predation.

INTRODUCTION

As a consequence of intense selection by natural enemies, insect herbivores that feed exposed on the leaf surfaces of their host plants have evolved an astonishing variety of defences to thwart enemies (reviewed by Ruxton, Sherratt & Speed, 2004). Chief among these anti-predator defences is camouflage, which includes many types of crypsis, disruptive coloration and background matching. Collectively, these strategies reduce the risk of prey being detected by potential predators (Cott, 1940). In an alternative form of camouflage, known as masquerade, protection is achieved through visual fidelity to innocuous, pedestrian objects common to the predator's surroundings (Endler, 1981; Stevens & Merilaita, 2009), such as a leaf, a twig or a bird dropping. The selective benefit of masquerade is thought to be independent of the background against which prey are viewed; masquerade relies on close fidelity of prey to a worthless, innocuous object. In contrast, the benefit of crypsis lies in the close mimetic relationship between the prey item and the prey's background or substrate (Endler, 1981). Skelhorn Skelhorn, Rowland & Ruxton, (2010a) propose that masquerade might be expected to occur most frequently in herbivorous insects, whose foraging behaviour is sedentary and

*Corresponding author. E-mail: fredric.vencl@stonybrook.edu

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Forage yield and carbon dynamics of mulberry fodder banks under varying density and harvest interval in coconut garden

Acsah Rose John, Asha K. Raj*, T.K. Kunhamu, E.V. Anoop and V. Jamaludheen

College of Forestry, Kerala Agricultural University, Thrissur - 680 656, Kerala.
**Corresponding author's Email: ashajayamohan@gmail.com*

ABSTRACT : In land crunch humid tropical regions like Kerala, the integration of protein rich mulberry hedgerows in coconut garden provides an excellent option to enhance quality forage production and carbon sequestration, but exhibit considerable variation to accumulate biomass and carbon under different management regimes. Hence, an attempt was made to assess the forage yields and carbon sequestration potential of mulberry fodder banks under three levels of plant density *viz.*, 49382, 37037 and 27777 plants ha^{-1} and three levels of harvest interval *viz.*, 8, 12 and 16 weeks, in coconut garden using 3 × 3 factorial randomized block design, replicated thrice. The results indicate that mulberry fodder banks yielded maximum dry forage (32.85 Mg ha^{-1} coconut garden over three year period) at the highest tree density of 49382 plants ha^{-1} and at 12 weeks harvest interval, when compared to other management options. In addition, the intercropped mulberry hedgerows has fixed more carbon to a maximum of 33 Mg ha^{-1} over three year period in the plant biomass and in soil up to 40 cm depth, when compared to coconut monoculture systems, thereby making considerable contribution for reducing atmospheric carbon dioxide levels to minimize global warming.

Key words: Agroforestry systems, carbon stocks, carbon sequestration, *Morus* and tree density.

Received on: 17.11.2018 Accepted on : 15.05.2019

1. INTRODUCTION

A major constraint to dairy farming in the humid tropics is the insufficient quantity and quality nutrition to livestock, along with seasonal fluctuation in fodder availability (Ajith *et al.,* 2012). This results in the dependence of farmers on high priced concentrate feeds that ultimately gives no net returns. Moreover, the majority grass vegetation available in the dry season is poor in digestibility, protein as well as overall nutrient content. Introducing fodder trees in the existing cropping systems is one of the promising ways for increasing production of protein rich fodder especially during lean periods, which can save farmers' expenses on costly concentrate feeds. In land crunch humid tropical regions like Kerala, coconut-based agroforestry system hold promise as a sustainable land-use activity and provide the scope for integrating fodder trees in the interspaces of coconut plantation, thereby increasing production and productivity per unit area with the optimum utilization of resources. Coconut is also an important plantation crop in around 15 states in India covering an area of more than 20 lakh ha (Coconut Development Board, 2017). Mature tall coconut gardens (>25 years) usually have better spatial advantage in crown spread and hence can allocate more light to the understory giving ample scope for intercropping.

Mulberry (*Morus* species), a multipurpose perennial tree, is well known for its nutritive foliage with high protein content and good amino acid profile, high digestibility, high mineral content, low fibre content and very good palatability. The high biomass yield of the plant together with its low tannin content make it an attractive fodder resource for ruminants particularly, as a supplement to low quality basal diets. There is evidence that mulberry foliage compares favorably to commercial concentrates, whilst maintaining optimum animal performance, through improvements in the rumen functions (Sanchez, 2002).

The production of leaf and total dry matter per ha of mulberry depends on the variety, location, plant density, fertilizer application and on harvesting techniques. Consequently, adoption of higher tree density and proper harvesting schedule can enhance forage productivity and quality from limited land area. Increasing plant density increases leaf and forage yields in mulberry as observed by Gong *et al.* (1995). Similarly, some workers suggested that 8-12 weeks pruning interval is most desirable for maximizing fodder yield in mulberry (Shelton *et al.*, 1996).

In an intercropping trial of mulberry fodder banks in coconut gardens of Kerala, Raj (2016) reported higher forage yield and nutritive value from high-density stands (49382 plants ha^{-1}) and at the shortest pruning interval of eight weeks compared to other management levels in the initial year of intercropping. However, due to the fast growing nature and vigorous rooting pattern of mulberry, both the above and below ground competition may increase with the advancing age especially under high density resulting in yield decline. Moreover, adoption of frequent harvesting over years may have a detrimental effect on tree health and productivity. Hence, a proper understanding of the long term impact of density and

Sl. No 11

Journal of Threatened Taxa

Building evidence for conservation globally

www.threatenedtaxa.org

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

COMMUNICATION

THE DIVERSITY AND DISTRIBUTION OF POLYPORES (BASIDIOMYCOTA: APHYLLOPHORALES) IN WET EVERGREEN AND SHOLA FORESTS OF SILENT VALLEY NATIONAL PARK, SOUTHERN WESTERN GHATS, INDIA, WITH THREE NEW RECORDS

C.K. Adarsh, K. Vidyasagaran & P.N. Ganesh

26 May 2019 | Vol. 11 | No. 7 | Pages: 13886–13909
DOI: 10.11609/jott.3856.11.7.13886-13909

Physiol Mol Biol Plants (September–October 2018) 24(5):963–971
https://doi.org/10.1007/s12298-018-0559-7

RESEARCH ARTICLE

Calcium alginate encapsulated synthetic seed production in *Plumbago rosea* L. for germplasm exchange and distribution

Anand Vishnu Prakash[1] · Deepa S. Nair[1] · Swapna Alex[1] · K. B. Soni[1] · M. M. Viji[1] · B. R. Reghunath[1]

Received: 29 December 2017 / Revised: 12 March 2018 / Accepted: 21 May 2018 / Published online: 3 June 2018

Abstract *Plumbago rosea* L. (Plumbaginaceae), is a medicinal shrub commercially exploited for its naphthoquinone principle, plumbagin, extracted from the roots especially for treating skin disorders. As the plant is exploited from the wild without being replenished, conservation of the species becomes inevitable. Synthetic seeds would provide for effective conservation, germplasm exchange and distribution of this species. A reliable protocol for synthetic seed production in *Plumbago rosea* has been developed encapsulating the axillary buds. The axillary buds from *P. rosea* cultures established and multiplied using the nodal explants in Murashige and Skoog (MS) medium supplemented with Benzyl Adenine (BA) 1.5 mg/L and Indole 3-Acetic acid 1.0 mg/L, were used for synseed production. The plantlet conversion efficiency was the highest in synthetic seeds developed with sodium alginate 2.5% in modified MS with 0.4 M sucrose and $CaCl_2$ 100 mM. This combination gave the earliest bud initiation (9.19 ± 0.39 days) and maximum number of shoots per explant (2.31 ± 0.16 shoots). Microshoots from the culture, when inoculated on to MS medium supplemented with Naphthalene Acetic Acid 1.0 mg/L gave the best rooting response with 10.67 ± 0.94 roots per plant and 5.42 ± 0.29 cm root length. This is the first report of synthetic seed production in *P. rosea* using axillary buds as explant.

Keywords *Plumbago rosea* · Synthetic seed · Germplasm exchange · Conservation

Abbreviations

BA	N6-Benzylaminopurine
Kn	Kinetin (6-furfurylaminopurine)
IBA	Indole 3-butyric acid
IAA	Indole 3-acetic acid
NAA	α-Naphthaleneacetic acid
MS	Murashige and Skoog
SA	Sodium alginate

Introduction

Plumbago rosea L. (Syn. *Plumbago indica*) of the family Plumbaginaceae, is a commercially exploited medicinal plant in the Indian system of medicine, Ayurveda. It is a bushy perennial shrub originated from India and South-East Asia. It is distributed widely in tropical and subtropical regions of the world especially in tropical Africa, tropical Asia and the Pacific region (Chuakul et al. 1999). In India, it is seen in Eastern Himalayas, South India, North East India and Madhya Pradesh (Sharma 2017). It's tuberous roots contains a quinoid constituent, plumbagin. Plumbagin is reported to have antibacterial, antifungal, anti-inflammatory and antiproliferative activities (Anuf et al. 2014; Kaewbumrung and Panichayupakaranant 2014; Xue et al. 2016). The plant is utilized in various Ayurvedic pharmaceutical formulations for treating cough, bronchitis, gastrointestinal disorders, skin disorders etc. Oh et al. (2017) reported the inhibitory effect of plumbagin on pigmentation and its efficacy to be used as a safe component in skin-care cosmetic formulations. Inspite of its huge demand in traditional pharmaceutical and cosmetic

✉ Deepa S. Nair
deepaanil13@gmail.com; deepanair.s@kau.in

[1] College of Agriculture, Kerala Agricultural University, Vellayani, Thiruvananthapuram, Kerala 695522, India

Journal of Tropical Agriculture 56 (2): 201-205, 2018

Short Communication

Biological efficiency of chilli + amaranth intercropping system under fertigation

Anitrosa Innazent, S. Anitha *, C. George Thomas, K.P. Prameela and V. I. Beena

College of Horticulture, Kerala Agricultural University, Vellanikkara, Thrissur - 680 656, Kerala, India

Received 18 June 2018; received in revised form 11 September 2018; accepted 01 December 2018

Abstract

An experiment was conducted at Water Management Research Unit, Vellanikara during January to July 2017 to study the biological efficiency of chilli+ amaranth intercropping system under different nutrient and water regimes. The treatments consisted of chilli + amaranth intercropping system planted at two different planting geometries *viz*., normal row planting and paired row planting, three nutrient levels *viz*., 100, 75 and 50 per cent NPK recommendation of both crops as fertigation and two irrigation levels *viz*., 100 per cent Epan and 75 per cent Epan along with two controls *viz*., chilli pure crop and amaranth pure crop. Biological efficiency of intercropping system was assessed by calculating LER, LEC, ATER, RCC and CEY. Chilli + amaranth intercropping under normal row planting produced significantly higher LER (2.84) compared to paired row planting. The intercropping system fertilized at 100 per cent of the recommended NPK dose to both crops showed the highest LER (2.81) compared to lower doses. Irrigation at 100 per cent Epan recorded significantly higher values of LEC (1.54) and ATER (2.56). Chilli equivalent yield was higher in chilli+ amaranth intercropping system (16553 kg/ha) compared to pure crop. The higher values of LER (>1.0), LEC (> 0.25), ATER and CEY revealed the biological efficiency of chilli + amaranth intercropping system compared to pure crop system.

Keywords: ATER, CEY, Intercropping, LEC, LER, RCC.

India ranks second in vegetable production, next only to China, and contributes about 12 percent of the world's production. The estimated production of vegetables in Kerala is 8.25 lakh MT as against the requirement of 36.7 lakh MT with practically little scope for horizontal expansion of the area under cultivation. Hence technology needs to be generated to include vegetables in the intercropping systems. Intercropping will help to increase total production per unit land per unit time. Productivity of intercropping systems can be enhanced by curtailing inter and intra species competition for various resources. This is possible by selecting compatible crops, adopting suitable planting geometry and proper water and nutrient practices. Fertigation is widely popularized as an efficient and economically viable method for water and nutrient management, on account of its highly localized application and flexibility in scheduling water and fertilizer applications. Research works on optimal schedules for micro-irrigation, fertigation and planting geometry in intercropping systems are very limited. The present study was done against this back drop and to assess the biological efficiency of chilli + amaranth intercropping system under different nutrient and water regimes.

The experiment was conducted at Water Management Research Unit, Vellanikara from January to July 2017 in randomized block design with three replications. Chilli variety (Ujwala) with longer duration (150 days) and wider spacing was taken as the base crop, and amaranth (Arun) with shorter duration (75 days) and closely spaced was

*Author for correspondence: Phone: 9446433292, Email: anitha.sarala@gmail.com

Indian Journal of Weed Science **50**(1): 27–32, 2018

Print ISSN 0253-8040 Online ISSN 0974-8164

Morphological characterisation of weedy rice morphotypes of Kerala

K. Anjali, M. Ameena* and Nimmy Jose[1]

Department of Agronomy, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala 695 522

[1]Rice Research Station, Moncompu, Aleppey, Kerala 688 503

**Email: drameenaubaid@gmail.com*

Article information

DOI: 10.5958/0974-8164.2018.00006.0

Type of article: Research article

Received : 4 January 2018
Revised : 7 February 2018
Accepted : 11 February 2018

Key words

Morphological characterisation
Morphometric character
Morphotypes
Qualitative traits
Quantitative characters
Seed bank
Weedy rice
Yield

ABSTRACT

Weedy rice (*Oryza sativa* f. *spontanea*) has emerged as a major threat to global rice production and has already established in the major rice growing tracts of Kerala, *viz*. Palakkad, Kuttanad and Kole lands. The main objective of the study was to compare the morphological characteristics of weedy rice morphotypes across the state so as to chalk out morphometric relationship between the weedy and cultivated rice at different stages of plant growth. Different morphotypes of weedy rice were collected from the major rice tracts of the state and characterization was done, both for qualitative and quantitative (morphometric) traits. The study revealed similarity in most of the qualitative traits observed for weedy and cultivated rice. The morphometric characters that varied significantly between weedy and cultivated rice during the initial stages of growth included thickness of culm and length of ligule. Most striking difference observed was in the number of tillers/plant with 87 per cent of weedy rice morphotypes recording higher tiller number (ranged from 11 to 20) compared to cultivated rice (10 and 9 for '*Jyothi* (Ptb-39) and '*Uma-MO-16*, respectively). Studies also revealed that weedy rice plants were lanky, taller (105 to 115.67 cm) with more round culm, with or without anthocyanin pigmentation at the nodal region, short ligule, early flowering compared to cultivated rice, more number of tillers per plant and mostly with awned grains. Similarities between weedy and cultivated rice were found to increase after every cultivating season due to the repeated back crossing and gene flow between the two plant types as evident from compact panicles and awnless grains observed among the morphotypes. As weedy rice invasion reduces crop yield substantially (40-70 percent), its management is an urgent need of the hour. Some of the morphological adaptations exhibited by the morphotypes in response to the prevailing ecological situations clearly indicated the possibility of weedy rice becoming a persistent threat to rice cultivation. Morphological characterization could help in identifying the competitive traits of weedy rice morphotypes which can be used in advanced breeding programmes for developing ecofriendly weedy rice management strategies.

INTRODUCTION

The introgressed product of wild and cultivated rice widely known as weedy rice (*Oryza sativa* f. *spontanea*), was first documented in North Carolina, USA as early as in 1846 (Smith 1981). However, reports of weedy rice emerging as a major weed in the direct-seeded rice tracts of South East Asia appeared after more than a century.In direct seeded rice, this noxious weed emerged as a major threat with its huge seed bank in cropped fields favouring persistent invasion. In Asia, weedy rice infestation was first reported from Malaysia in 1988, Philippines in 1990, and Vietnam in 1994 (Saha *et al.* 2014). In India, the first attempt of identifying and characterizing different types of weedy rice in farmer's field was done in Madhya Pradesh (Varshney and Tiwari 2008). In South India, especially Kerala weedy rice infestation and spread has reached an alarming proportion in major rice tracts during 2007-08. The weed then evolved as a major problem in the rice fields reducing the yield from 30 to 60 per cent at an infestation rate ranging from 3 to 10 mature plants per square metre (Abraham *et al.* 2012). Of late, it has infested large rice growing areas across the major rice belts of Kerala, *viz*. Palakkad, Kuttanad and Kole lands with

Journal of Crop and Weed, 14(3): 130-135 (2018)

Management of weedy rice (*Oryza sativa* f. *spontanea*) by enhancing rice competitiveness

K. ANJALI, M. AMEENA AND [1]N. JOSE

Department of Agronomy, College of Agriculture
Vellayani-695522, Thiruvananthapuram, Kerala
[1]Rice Research Station, Moncompu, Alappuzha, Kerala

Received : 14-09-18 ; Revised : 28-11-18 ; Accepted : 02-12-18

ABSTRACT

Of late, weedy rice (Oryza sativa f. spontanea) has emerged as a major weed in the traditional and nontraditional rice belts of Kerala. The objective of the study was to investigate the possibility of increasing crop competitiveness to weedy rice by adopting high seed rates of 100,120 and 140 kg ha^{-1}along with two priming techniques viz., water and 2.5% KCl. Among the priming methods tested, hydropriming showed superiority over hardening with 2.5% KCl. Number of grains panicle^{-1}, chaff percentage, grain and straw yield were significantly influenced by high seed rate (100 or 120 kg ha^{-1}) along with hydropriming. Seed rate of 100 kg ha^{-1} along with hydropriming recorded the highest number of grains (120.02 and 121.76 respectively) per panicle followed by seed rate of 120 kg ha^{-1} with hydropriming. Better crop stand from hydroprimed seeds sown at 120 kg ha^{-1}resulted in rapid canopy development and gave preliminary advantage to rice plants over weedy rice.Weedy rice count and dry weight showed a decline on sowing of hydroprimed seeds at 100 or 120 kg ha^{-1}, with weed control efficiencies of 52 and 51per cent respectively. The study revealed a positive relation between rice competitiveness and hydropriming of seeds upto 120 kg ha^{-1}. While yield increase of 10 per cent was recorded for hydroprimed seeds at 120 kg ha^{-1}, yield reduction of 39 per cent was recorded at 140 kg ha^{-1}. Hydropriming of seeds at a rate of 100 or 120 kg ha^{-1} followed by pregermination could be recommended as one of the management practices for enhancing rice competitiveness to manage weedy rice infestation in wet seeded rice.

Keywords: Competitiveness, hydro priming, seed rate, weedy rice and wet seeded rice

To cope up with the problems associated with labour shortage and water scarcity, farmers are forced to shift from puddled transplanted rice to direct seeded rice (DSR). Though DSR has many benefits like early and easy crop establishment, lower water requirement and less labour requirement, one of the major threats that has evolved by continuous adoption of this system is the emergence of one of the most invasive weeds in rice field *i.e.* weedy rice (*Oryza sativa* f. *spontanea*). It is similar to cultivated rice in most of the attributes and very difficult to identify during the initial stages. Weedy rice is regarded as the most problematic weed of 21st century and has already invaded the major rice growing states of the country with an infestation level of 5 to 60 per cent (Varshney and Tiwari, 2008). Of late, the weed has become a serious threat in the major rice growing tracts of Kerala like Palakkad, Kuttanad and Kole lands. Abraham and Jose (2014) reported non-recognition of weedy rice biotypes or hybrids in the crop field during the early stage of infestation due to its close similarity with cultivated rice as the primary reason for its alarming spread.

Weedy rice shares traits of both cultivated as well as wild rice types as it is a conspecific taxon of the AA genome complex of rice. It usually flowers earlier than cultivated rice, has a pigmented caryopsis, pigmented hulls with or without awns and its grains shatter easily, thus enhancing the weed seed bank (Rathore *et al*., 2013). Hand weeding is practically not feasible in heavily infested fields and by the time of panicle initiation during which the morphological differences are clearly evident serious damage would have been occurred to the crop. Weedy rice has competitive advantage over cultivated rice as it grows taller and faster, tillers profusely and competes with cultivated rice for nutrients, light and space. Important traits for the success of weedy rice invasion are early shattering of the grains and variable seed dormancy (Chauhan, 2013).

Yield loss under weedy rice infestation ranged between 60 to 80 per cent under moderate (15-20 weedy rice panicles m^{-2}) to high (21-30 panicles m^{-2}) infestation (Azmi and Karim, 2008). Yield of tall and short rice cultivars are reduced by 60 and 90 per cent respectively by weedy rice densities of 35 to 40 plants m^{-2}, indicating greater loss associated with weedy rice than other grassy weeds (Kwon *et al*., 1991). High seeding rates improve the ability of crop to suppress weeds more effectively by facilitating quick canopy closure (Chauhan and Johnson, 2011). Seed priming is expected to improve the competitive ability of crop against weeds with faster emergence and increased vigour which are the key factors for weed suppression. In this backdrop, the present investigation was undertaken to study the combined effect of high seed rate and seed priming on enhancing rice competitiveness for management of weedy rice.

Email: drameenaubaid@gmail.com

Indian J. Agric. Res., 53(1) 2019: 17-24
Print ISSN:0367-8245 / Online ISSN:0976-058X

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Productivity of grain cowpea in high phosphorus soils as influenced by nutrient interactions

V. Anjaly and Sheeba Rebecca Isaac*

Department of Agronomy,
College of Agriculture, Vellayani, Thiruvananthapuram-695 522, Kerala, India.
Received: 04-09-2018 Accepted: 29-10-2018 DOI: 10.18805/IJARe.A-5121

ABSTRACT

A field experiment was conducted in a high phosphorus soil in the southern district of Kerala during January to March 2018 to assess the effect of varying levels of P, K and Zn and their interactions on the productivity of grain cowpea. The treatments included two levels of P, three levels of Zn and two levels of K and was laid out in factorial RBD with three replications. The results of the study revealed that significantly higher yield attributes and yield (pod and grain) were realized through foliar application of Zn as $ZnSO_4$ twice @ 0.025% at branching and at flowering, along with 10 kg K_2O ha^{-1} in the high P soil. The yield was 58 per cent higher than the yield at the lower levels of P, K and Zn tried. Economic analysis also revealed higher benefit cost ratio (1.36) for the combination. Phosphorus application may be skipped in the nutrient package for grain cowpea in high soils. Based on grain yields, it could be interpreted that a negative interaction existed between P and Zn and also between Zn and K. The interaction between P and K was not significant.

Key words: Cowpea, Interaction, Nutrient, Phosphorus, Potassium, Zinc.

INTRODUCTION

Phosphorus nutrition has received wide attention with the increased use of fertilizers in crop management and the subsequent build up of P in soil (Withers *et al.*, 2001). The nutrient has specific role in plants being part of the chemical structure of nucleic acids, co- enzymes, proteins, phospholipids and is crucial for energy transfer. According to reports, consumption of rock phosphate in 2016-17 was twice that in 2015-16 and in amophos, it was 100 percent of its production in the country (FAI, 2018). The dynamics of P in soil is controlled by the adsorption and fixation reactions in soil (Sanyal and Datta, 1991), as a result of which continued application of P fertilisers can lead to the accumulation of the nutrient in soil. This has a marked influence on the availability of other nutrients and hence P management in these soils is of paramount importance.

Cowpea [*Vigna unguiculata* (L.) Walp] is a quick growing short duration pulse crop that fits well in almost all cropping systems. The nutritional importance of the crop as a good source of protein, calcium, iron, dietary fibre, uses as food, feed, forage, fodder are indisputable. Anitha *et al.* (2006) had recorded that cowpea ranks first among the pulses cultivated in Kerala. Although pure crop cultivation of cowpea is not extensive, it is commonly grown as intercrop in perennial crop combinations and as catch crop in summer fallows.

Phosphorus is an important nutrient in legume production systems on account of its role in nitrogen fixation (Walley *et al.*, 2005). Soil test values of more than 25 kg available P ha^{-1} are rated as high and such excess levels of P are reported in the southern laterite soils of Kerala (KSPB, 2013). The high P status is expected to have a positive influence on the growth and yield of the legume. Tomar *et al.* (1994) had documented that high P contents in soil adversely affect the availability of the micro nutrient, zinc in plants. Kumar *et al.* (2016) also observed that availability of Zn in soils and its absorption and translocation in plants are influenced by other plant nutrients especially P. Zinc is critical especially in legumes as it facilitates protein synthesis, energy production, gene expression and also maintains structure of enzymes (Habbasha *et al.*, 2013). Potassium is involved in enzyme activation, photosynthesis, transport of sugars, protein and starch synthesis (Tiwari *et al.*, 2002). Daliparthy *et al.*(1994) reported that increasing levels of K can reduce the severity of P induced Zn deficiency in plants. Thus, in a P rich soil, nutrient management practices should emphasize on balanced nutrition taking into account the interactions that can occur and influence crop performances. It is in this background that a study was undertaken to evaluate the effect of different levels of P, K and Zn on productivity of grain cowpea in a P rich soil of southern Kerala.

MATERIALS AND METHODS

The field experiment was conducted in a farmer's field in Thiruvananthapuram district, south Kerala during January to March 2018. The site situated at 8.43°N latitude,

*Corresponding author's e-mail: sheeba.issac@kau.in

Journal of Agrometeorology 21 (1) : 114-118 (March 2019)

Short Communication

Biotic indicators as weather predictors in Wayanad district of Kerala

R. ANJU [1]* and BINOO P. BONNY[2]

[1]Academy of Climate Change Education and Research,

[2]Communication center, Kerala Agricultural University, Thrissur, 680 656, Kerala, India.

**Author for correspondences: Email: anjurp95@gmail.com*

Weather is certainly the most important factor determining the success or failure of agriculture. It forms the only factor over which farmers have no control. It directly influences the growth, development and yield of crops (Verma, 1998). Before the advent of modern methods of weather forecasting the rural communities used ITKs for weather prediction. The correct predictions are dependent upon the correct interpretation of indicators which is based on experience, skills and in sights of people and were applied to minimizing the risks rather than maximizing profits. Weather forecast describes the anticipated meteorological conditions for a specified place (or area) and period of time. Farmers are very astute weather watchers and they use different kinds of indigenous knowledge to predict weather. This knowledge is generally passed down from generation to generation by experimental learning and by word of mouth and is, for the most part, undocumented in written form. These local indicators and local knowledge systems cannot be replaced with scientific knowledge, as they are holistic and specific to local situations. They provide farmers with the ability to make decisions and plan in advance mostly making use of the local resources.

The study was conducted in Padinharethara, Vellamunda, Nenmeni and Mullankolly panchayats of Wayanad district of Kerala. Random sampling was followed to select 25 farmers from each of the four selected panchayats to make a total sample of 100 farmers. In addition, 20 key informants were selected purposively from the Department of Agriculture Development and Farmers Welfare, Non-Governmental Organizations working in the area viz. Wayanad district Adivasi Youvajana Samithy, Wayanad Social Service Society, M. S. Swaminathan Research Foundation, Malanad Charitable Society and Sulthanbathery Mannam Social Service Society, and Farmer Interest Organization viz. *Karshagasangams/ samathy* working with traditional farmers/ indigenous/ tribal groups. Exhaustive sampling was followed to include all the four blocks (Mananthavady, Kalpetta, Sulthanbathery and Panamaram) of the district for the study. Based on area under cultivation and crop damage reported under natural calamity during the past three years (2015, 2016, 2017), one panchayat each was selected from all the four blocks.

The survey of the study area was conducted in the month of December 2017- February, 2018 using standardized measurement instruments developed for the purpose. Identification and documentation of indigenous weather forecasting practices was done with the help of key informants from different parts of Wayanad. Personnel interview method using open-ended schedules were used to collect the data. In order to ensure the collection of meaningful information, participatory tools like Focus Group Discussions (FGD) were also used involving expert farmers/ key informants, and irrelevant and irrational practices were screened off. A list of 35 biotic weather forecasting practices were identified and documented for the study (Table 1,2,3).

Validation was operationalized as the process of checking the quality of recorded ITKs in terms of its logical and factual exactness. The ITKs were validated through farmer participatory process using Use validity score (UVS) developed for the purpose and also authentication using published research findings/ theories where ever possible. Use validity of a particular ITK was measured on three dimensions viz. purpose of use (PU), extent of use (EU) and perceived reliability (PR). Raw use validity score was calculated for each of the dimensions with the maximum possible score 12 and minimum possible score 3 (Fig.1). A score sheet was prepared using the above scoring pattern for each individual farmer. The use validity score (UVS) was developed as sum of product of each component score (PUscore, EUscore, PRscore) and their respective weightage (Wpu, Weu, Wpr).

$$UVS = (Wpu * PU\ score) + (Weu * EU\ score) + (Wpr * PR\ score) \quad \ldots\ldots\ldots (1)$$

Where,

Indian Journal of Traditional Knowledge
Vol 18(3), July 2019, pp 565-572

Indigenous knowledge based abiotic indicators used in weather prediction by farmers of Wayanad, Kerala, India

R Anju[1] & Binoo P Bonny*[,+]

Academy of Climate Change Education and Research (ACCER), Kerala Agricultural University, Thrissur 680 656, Kerala, India

E-mail: [+]binoobonny@gmail.com; [1]anjurp95@gmail.com

Received 09 June 2018; revised 10 May 2019

The paper presents twenty abiotic indicators used by farmers for weather prediction in Wayanad district, Kerala. These indicators were based mainly on the appearance of sky, color and patterns of cloud, moon, wind, rainbow and temperature. The popularity of these indicators among farmers was measured using use validity score (UVS) based on purpose of use, extent of use and perceived reliability. With this score, we categorized the indicators into high, medium and low popularity classes. Five indicators were assessed as high popularity, four as low popularity and the remaining, medium popularity.

Keywords: Indigenous knowledge, Kerala, Weather indicators, Use validity score (UVS)

IPC Code: Int. Cl.[19]: A61K 36/00, A01D 67/02

Weather is the most important determinant of the success or failure of agricultural enterprises, with a profound influence on crop growth, development and yield[1]. The vulnerability caused by weather uncertainty is embodied in the Indigenous Technical Knowledge (ITK) systems of farmers. ITK is the sum total of knowledge and practices based on people's accumulated experience in dealing with problems related to various aspects of life[2]. ITK is unique to a culture. Largely undocumented and generally passed on from generation to generation through experimental learning processes and word of mouth, ITK-based weather forecasting practiced by humans for millennia helps to reduce uncertainty in agriculture. Before the advent of modern weather forecasting methods, rural communities used ITK, mostly based on observations of atmospheric conditions, astronomic and relief features, to predict weather over short and long periods. Accuracy of predictions was dependent upon the correct interpretation of indicators, which were in turn developed through experience, skills and insights of people over generations. This paper presents indigenous knowledge of abiotic indicators used by Wayanad farmers for weather prediction, validated through farmer participatory processes.

*Corresponding author

Methodology

Study area: Wayanad district in Kerala, between North latitudes 11°26′ to 12°00′ and East longitudes 75° 75′ to 76° 56′, at altitudes of 700 to 2100 meters above mean sea level, was purposefully selected for the this study (Fig. 1), since the district represents one of the four climate change hotspot districts in Kerala. Moreover, this district was considered a rich repository of indigenous knowledge in agriculture, with impressive ethnic diversity of population with ten indigenous tribal groups. Thus all sources of Indigenous Knowledge are represented here.

Sampling: Exhaustive sampling was followed to include all the four Blocks of the district viz. Kalpetta; Mananthavadi; Sulthanba therry; and Panamaram. Purposive sampling based on area under cultivation and reported crop damage through natural calamity for the period 2014-2016 was used to select one panchayat from each of the four blocks. The panchayats selected for the study were Padinharethara (Kalpetta block); Vellamunda (Manathavadi block); Nenmeni (Sulthanbatherry block); and Mullankolly (Panamaram block). Twenty-five farmers from each panchayat were randomly selected, for a total sample of 100 farmers. In addition, 20 key informants were purposively selected from the officers of the Department of Agriculture Development and Farmers Welfare, and 10 major Non-Governmental