

## CHAPTER 5

### CURRENT STATUS AND FUTURE CHALLENGES IN IMPROVEMENTS OF CLUSTER ONION IN SRI LANKA

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#### **Abstract**

Onion research in Sri Lanka began in early 1960s at the Field Crops Research and Development Institute (FCRDI), Mahalluppallama and Agriculture Research Station, Thirunelvely (synonymous Thinnavelly). Variety selection and other agronomic studies were done earlier but a systematic breeding program on shallot onion was initiated in late 1990's. Many land races were characterized and evaluated. Agronomic evaluation has resulted in differentiating three major types; Vethalam, Vallari and Jaffna Local. Among these types variation in genetic distance and the genetic diversity was reported. Confusion in nomenclature in red onion landraces was cleared. Series of field research studies and farmer field experiments with different maturity groups in different locations in Sri Lanka has resulted in releasing a new cluster onion shallot type, Thirunelvely Red for the Northern region in 2009. Thirunelvely Red is well adapted high yielding and early maturing variety. In addition, programs at Regional Agriculture Research and Development Centre (RARDC), Aralaganwila and Thirunelvely also identified three promising lines; ACC 66, TVM-1 and TMV-6. TVM-6 which were field tolerant to major fungal diseases. Since 1998, onion breeding program of RARDC, Aralaganwila focused mainly on cluster onion improvement with the aim of increasing quality and yield. In 1996, a hybridization program was initiated with reciprocal crosses between six parental combinations. A high bolting line was identified by FCRDI, Mahalluppallama. Finger printing studies also confirmed the variability among exotic and local collections. Presently, studies are being focused in achieving realizable potential yield of 18 mt/ha to increase the present national productivity of 11.2-15 mt/ha. Attempts are also being made to develop

**hybrids. Techniques for reducing the cost of planting materials and increasing stress tolerance are included in future breeding programs.**

## **Introduction**

Onion is the most important species of *Allium* group belonging to family Alliaceae. The monocot genus *Allium* is a large genus with more than 500 species. Out of these, only seven species are in cultivation. However, *Allium cepa* L. and *Allium sativum* (Garlic) are the two major cultivated species grown all over the world. Onion (*A. cepa*) is a biennial but is usually grown as an annual crop. The varieties belonging to multiplier onion and shallot subgroups are classified as “small onions”. These two subgroups are most important in *Aggregatum* group of *A. cepa* in Sri Lanka (Sumanaratne *et al.*, 2002; 2005). China, India, USA, Russia and Spain are the leading producers of onion. In terms of area, India ranks first in the world with over 480,000 ha but the highest producer is China.

Onion is believed to be brought by ancient traders from Tamil Nadu, especially to the Northern Sri Lanka and later spread to other parts of the country (Arasakesry and Jehanathan, 2005). Red Onion is grown over an area of over 3,000 ha in Sri Lanka with a production of over 64,000 mt in 2013 (DCS, 2014). Both shallots and multipliers are being widely cultivated in Sri Lanka. Until recently local landraces are being cultivated as a cash crop and maintained by storing bulbs under natural conditions. Studies by Sivalingum and Kandiah (1967) on shallot type flowering strain was reported where seedlings were transplanted from lines with around 80% flowering and seed yield of about 114 kg/ac (FCRDI, 1967-2014). It was reported that in 1969 cluster onion varieties from Thailand, Phillipines, and also Vethalam were evaluated at Mahalluppallama. In 1970 and 80s’ further research have been conducted on red onion using both land races and introductions (FCRDI, 1967-2014).

However, information on systematic crop improvement research on red onion in Sri Lanka was not available until recently. Therefore, this paper highlights the present status and future challenges of crop improvement research carried on red onion by the Regional Agriculture Research and Development Centre (RARDC),

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Killinochchi and Aralaganvila and Field Crops Research and Development Institute (FCRDI), Mahailuppallama.

### **Crop Improvement of Onion in Northern Region of Sri Lanka**

#### ***Germplasm collection, characterization and evaluation.***

In the past red onion landrace have been evolved without systematic or sustained plant breeding efforts. Studies on selection of red onion lines were initiated at the Agriculture Research Station (ARS), Thirunelvely in late 1960's using germplasm available in the region. At the same time, studies on red onion were also conducted at FCRDI, Mahailuppallama (FCRDI, 1967-2014). Thereafter, work on red onion was also started at the RARDC, Aralaganwila in mid-1990's (RARDC, 1995-2014). Studies were reinitiated in 2002 at the ARS, Thirunelvely to expand the genepool, create diversity and to subject them to possible selection and hybridization program (ARS, 2002-2003). Sixteen onion germplasm lines collected from Jaffna district have been evaluated for their agronomic traits to identify genetic variability adapted to various soil types and climatic condition (Singh, 2000). Morsy (2011) suggested that range in size, colour, pungency and taste depending upon the variety of onion. Traditionally, three major landraces, Jaffna Local, Vallari and Vethalam have been grown in the Northern region (Arsakesary and Jehanathan, 2005). However, many landraces cultivated in the region were found to be mixtures and are grown in different parts with different names which had caused confusions in the nomenclature of red onion. Therefore, knowledge on materials available in the Northern region along with their descriptors became imperative for further advancement of this crop (ARS, 2002-2003). Therefore, a purification program was initiated in these landraces simultaneously and completed in *maha* 2003/04.

Characterization and evaluation has grouped these 16 landraces into six major types *viz*; Vethalam, Murivethalam, Vadali Vethalam, Kalvethalam, Vallari and Jaffna Local. First five types could be classified as multipliers while the last one belongs to shallot type. Vethalam might have been introduced through Vetharniyam and this south Indian name of Vetharniyam town has been in use as the name of this landrace. In the past these Tamil names were given based on their

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unique characteristics, i.e. Murivethalam (Murri=fallen or broken) leaves were fallen abruptly on maturity; Kal vethalm (Kal=stone) bulbs appears like a small round stone which is heavier to its size; Vaddali Vethalam looked like young palmyra in the field; Vallari is meaningless however it might have attained this name due to its town of origin; Sinna vengayam (Sinna=small) is relatively small in size. These landraces showed significant differences in bulb characteristics and days to maturity between and within the groups. Major types had significant difference among these characters. The difference in bulb weight between Vethalam types may be attributed to their flowering behaviour. Vallari and Jaffna Local produces lighter bulbs than the rest. Bulbs of Vallari were heavier than that of Jaffna Local (Arasakesary *et al.*, 2005). In general, bulb weights were more in *maha* season than in the *yala* season.

A molecular study carried out with 10 promising landraces using six primers amplified 31 bands out of which 14 have been polymorphic. Vethalam (JVM 302) can be identified with the single band in contrast to the rest of the accessions with two bands can in primer OPD 15. Results depicts that all selected 10 accessions of 16 tested under field condition are genetically diverse. This diversity revealed that farmer field collections grouped with their traditional names based on their characteristics could be identified as different landraces. According to the dendrogram five distinct clusters can be identified. In addition, landraces have shown a remarkable difference between the groups and notable difference among the group (Arasakesary *et al.*, 2005). Though six types in two major groups have been found, traditionally in Northern region only five major clusters have been observed on these red onion landraces by using molecular markers. Further evaluations of purified stock of landraces are continuing.

### ***Release of Thirunelvely Red – a new cluster onion variety for the Northern region***

After series of fields' research and farmer field experiments, the first high yielding, short duration cluster onion line has been released in 2009 as Thirunelvely Red for cultivation in the Northern region. It was the first cluster onion variety developed through a systematic breeding approach in Sri Lanka (DOA, 2009). This variety is confirmed as a mutation from variety Vethalam (Arasakesary *et al.*, 2005).

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### ***Major cultivars in multiplier onion***

Agronomic evaluation, characterization, RAPD analysis and the farmers' knowledge helped to separate these germplasm into three major groups as mentioned earlier. However, multipliers fetched different identities in later studies as they differed in their maturity, bulb shape, bulb weight, bulb skin colour, pungency and storability (ARS, 2004). These true variations in agronomic traits among these cultivars have also been confirmed by molecular studies (Arasakesary *et al.*, 2005).

### ***Rapid exploitation of hybrid vigour through naturally out crossed onion population***

Even though reports indicate a true seed onion cultivation at FCRDI in 1970's, red onion is usually being cultivated through seed bulbs while few plants recorded flowering and seed setting in *maha* season. Seeds of these plants have been further tested and MH3, MH4, MH5 and MH 6 have found to be flowering during *yala* season even without vernalization (ARS, 2003-2006). Among them MH 4 (accession 4; ACC 4) which had 100% flowering was promoted for further studies on true seed cultivation in Northern region. Bulbs of ACC 4 which need no vernalization even in *yala* seasons have been distributed among the farmers in Northern region.

### ***High yielding multiplier onion line - TVM-1***

National coordinated trials have been conducted using 60 days and more than 70 days maturity groups of both shallot and multipliers and TVM-1 performed well in all locations. Variety Adaptability Trials (VAT) in different agro ecological zones also confirmed that TVM-1 was a higher yielder. This line will be further tested in farmer's fields (ARS, 2007-2013).

***A multiplier with high flowering and field tolerant to major fungal diseases***

Filed screening studies for diseases at ARS, Thirunelvely revealed that TVM-6, though relatively lower yield has performed well against bulb rot, anthracnose and purple blotch under field condition (ARS, 2013; ARS, 2013-2014). In separate studies conducted at RARDC, Killinochchi, TVM-4 has produced more flowers and set more seeds and their flower stalks were not affected by anthracnose in late *maha* indicating the resistance (Araskesary *et al.*, 2014). Further evaluation of disease resistance is continuing.

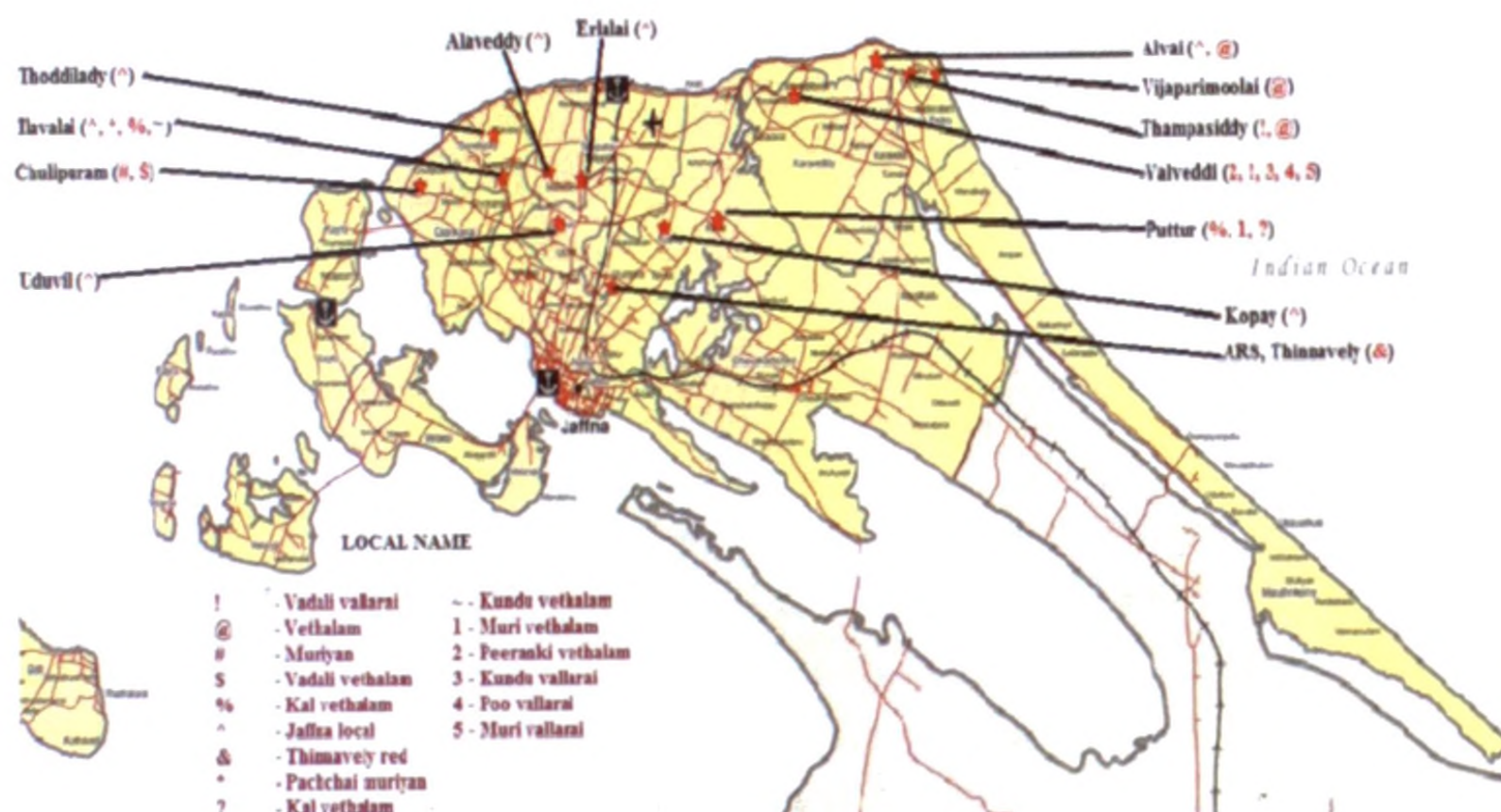
***Recent studies on agronomic characterization and molecular separation of onion landraces in Jaffna district.***

Twenty six germplasm lines collected from farmers' fields in Jaffna district (Map 1) (Araskesary *et al.*, 2014) were characterized for plant height, leaf width, bulb shape, size, maturity group, TSS, leaf colour, bulb colour and yield potential. This study identified three major types of germplasm with three different maturity durations and yield potential. Further, confirmation of these germplasm lines were done by developing finger prints using appropriate molecular techniques at the FCRDI.

**Onion Improvement Program at RARDC, Aralaganwila**

Since 1998, RARDC, Aralaganwila focused mainly on cluster onion improvement program with the aim of increasing quality and yield of red onion (RARDC, 1995-2014). In 1995, among 6 different cultivars, Vethalam and Agrifound Rose have been identified as better bolting cultivars (RARDC, 1995-2014). In 1996, hybridization program with reciprocal crosses have been started between Vethalam and Agrifound Rose (RARDC, 1995-2014). Further, reciprocal crosses between Vethalam x Kalpitiya Selection, Jaffna Local x Agrifound Rose, Vallari ACC 3 x Agrifound Rose, Vallari ACC 5 x Agrifound Rose and Rambawa White x Vethalam have also been conducted for hybridization (RARDC, 1995-2014). *Yala* season has been identified as the most suitable for true seeds production from these cultivars (RARDC, 1995-2014). Investigation on varietal performance

and regional suitability of available germplasm commenced from 2000/2001 *maha* season. Vethalam, Vallarai and ACC 5 were significantly higher yielders compared to Jaffna Local and Agrifound Rose.



Map 1: Geographical locations of 26 onion germplasm collected from the Northern region.

Preliminary Evaluation of inter varietal crosses continued and better performing lines (Vethalam x Kalpitiya Selection, Vethalam x Agrifound Rose, Rambawa White x Agrifound Rose and one exotic line) were selected for the major yield trial (RARDC, 1995-2014). Jaffna Local and Thelulla selection (ACC 7) were identified as the early maturing cultivars but their yields were lower than others lines tested.

Twenty two accessions including 8 local collections, 4 exotic lines (Indian and Thailand), 6 inter-varietal crosses and 4 lines from Plant Genetic Resource Centre were characterized in 2003/04 *maha*. Characterization continued in subsequent seasons (RARDC, 1995-2014) and selected lines were tested under PYT and MYT. Six lines of shallot sub group with the check line of Jaffna Local and 8 lines of multiplier group with the check lines of Vethalam and Agrifound Rose were tested under NCVT in 2005 *yala*. By using morphological traits, isozymes and randomly amplified polymorphic DNA markers, confirmed the hybridity of onion

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crosses and estimated genetic diversity of the available germplasm (42 accessions). Selected crosses carry a wide genetic base, as the parents are genetically wide apart. Therefore, vegetative propagation of these hybrids or advancing generation for further selection was continued. Ten lines of multiplier with Vethalam and 7 lines of shallot with Jaffna Local were tested in 4 locations from 2005 *yala* (RARDC, 1995-2014). Based on these and Variety Adaptability Trial (VAT) results, ACC 18 was identified as better performing exotic shallot line. Thus, further characterization and DUST test are being carried out at RARDC, Aralaganwila.

### **Current Status of Onion Research at RARDC, Aralaganwila**

Onion improvement program continued and a high quality bulb rot tolerant line, ACC 16, bolting line, ACC 66 and high yielding TVM 1 and ACC 66 were selected and advanced to VAT at Kalpitiya, Moneragala, Jaffna and Aralaganwila. The local germplasm from main growing areas (Jaffna, Kalpitiya, Thellulla and Kollonna) and from the local market were collected for increasing the diversity. Characterization of 53 lines and selection is continued (Plate 1). Selection for bolting type onion from available germplasm is also being done using 22 lines under MYT. Evaluation of high quality cluster onion with high pungency (9) is also continuing under MYT. To identify lines for environmental variations, tolerant lines to biotic and abiotic stresses with short to medium duration are being tested with Jaffna Local and variety Thirunelvely Red under NCVT in 4 locations (Plate 2). Hybridization program (Plate 3) is continuing using artificial emasculation while investigation of Cytoplasm Male Sterile (CMS) lines using staining method and development of Male sterility using different concentrations (0.2-0.8%) of Gibberalic Acid are being tested with the aim of developing hybrids.

### **Cluster Onion Improvement Program at FCRDI, Mahalluppallama**

In 1967, studies on shallot type flowering stains reported that seedlings were developed and transplanted from lines with around 80% flowering and seed yield of about 114 kg/ac (FCRDI, 1967-2014). In 1969 cluster onion varieties from Thailand, Phillipines and also Vethalam types were evaluated. Thailand varieties matured within 80 days after planting (DAP) whereas Vethalam took 85 days to



Plate 1: Variation in germplasm available at RARDC, Aralaganwila.

mature. Philippine variety recorded lower yield but matured in 70 DAP. Thailand varieties produced large size sets and Local Red and Vethalam recorded more storage losses (FCRDI, 1967-2014).



**Plate 2: Testing of short age lines under NCVT (left) and selected flowering lines tested under MYT (right).**



**Plate 3: Multiplication of  $F_1$  generation and hybridization through emasculation.**

After a long gap, cluster onion research at FCRDI, Mahailuppallama was reinitiated and 7 seed setting cluster onion lines in *yala* 2009 and 2010 were evaluated. Those lines were evaluated with Vethalam during *yala* 2011 and two lines gave higher yields over Vethalam. Evaluation of cluster onion line MICLO.09-01 for true seed production was carried out in *maha* 2012/13 and *yala* 2013 at FCRDI. MICLO 09-01 reached to 50% flowering within 69-70 DAP irrespective of vernalization. Flowering of Vethalam depended on vernalization and 50% flowering completed within 52DAP which was 26 days earlier than other lines. It was concluded that MICLO 09-01 produced higher true seed yield than Vethalam.

Mother sets of both MICLO 09-01 and Vethalam should be vernalized to get higher true seed yield during *yala* season but it is not necessary to vernalize during *maha* season. Population improvement of cluster onion lines MICLO 09-01 was continued. Generation advancement of white cluster onion line, "MICLO 09-white" selected from same initial population of MICLO-09-01 in 2009 was maintained vegetatively during past 2 years. Red coloured cluster onion accession K-4 which was collected from PGRC had better flowering and generation advancement of those lines are in progress since *yala* 2012.

### ***Germplasm evaluation of cluster onion***

There is a need to develop high yielding, seed setting cluster onion varieties to increase the average yield to reach national targets. Seventeen cluster onion accessions were therefore evaluated during *yala* 2013 at FCRDI. MICLO-10-02, MICLO-10-03, MICLO-10-04, MICLO-10-06, ACC-09 and NO-05-01 were selected for further evaluation. The following germplasm are being maintained at FCRDI for future research (Table 1).

**Table 1: The germplasm maintain at FCRDI for future research.**

<b>Accession</b>	<b>Line No</b>	<b>Remarks</b>
ACC 02	C -2011-03-41	MICLO-09-01 White
ACC 09	C -2011-03-42	Moragollagama Selection
ACC 11	C -2011-03-48	Thirunelvely Red
ACC 21	C -2011-03-59	Vethalam
ACC 26	No.1	Rambawa White
K-4	No. 5	
K-9	No.-05-01	
K-10	MICLO-11-04	

### **Future Directions of Cluster Onion Research in Sri Lanka**

Shallot onion production which is about 75,000 mt at present should be increased to 120,000 mt to meet the national demand. This could be achieved by

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either increasing the area under cultivation, which is very limited or by increasing the productivity. The present average realizable potential of 15 mt should be increased to 18 mt to increase the national productivity of 11.2 to 13 mt.

Cluster onion improvement program is mainly focused on developing high yielding cluster onion lines. Further onion cultivation is threatened by diseases than pests which can be easily controlled with recommended chemicals. However, fungal diseases are major constraint in both shallot and multipliers. Tip burning in shallot types is also a problem especially in the dry season. Therefore, lines which are tolerant to major diseases are needed.

Identifying dual purpose short duration high yielding red onion lines are in progress using both conventional and other breeding techniques. Attempts are also being made to develop hybrids. Further, to overcome biotic stresses, lines tolerant to water stress and short duration are needed. Techniques for reducing the cost of planting materials and increasing the keeping quality are also essential. Confusion in the nomenclature is being cleared by germplasm evaluation, characterization and molecular studies in two different stages.

Onion seed costs more than 60 % of the total cultivation expenditure. Seed bulb production often fails due to bulb rot, anthracnose and nematode attack. Currently the true seed cultivation technique is in progress for which the seeds are imported. Farmers often complain that the imported lines are not uniform and less suitable to local conditions and lower storability. Many farmers are also involved in bulb seed production which is the main source of income for the farmers in the Northern region (Plate 4). Developing a dual purpose variety which can produce about 600-800 true seed and 7-10 seed bulbs per plant with longer storability is needed. Research on cluster onion at ARS, Thirunelvely, RARDC, Kilinochchi and Aralaganwila and FCRDI, Mahailuppalama will be further strengthened to achieve the above objectives.



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