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A PROMISING MULTIPLIER ONION (*ALLIUM CEPA*) LINE WITH FIELD RESISTANCE TO MAJOUR FUNGAL DISEASES AND POSSESING MODERATE FLOWERING EFFICIENCY

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ABSTRACT

Series of experiments were conducted with more than thirty cluster onion land races to characterize, evaluate and to screen for major fungal diseases in two locations since the year 2002. Characterization and their agronomic evaluation lead to group these entries as shallots and multipliers. Multipliers produced more than 30 t/ha and ranged in their maturity from 63 to 81 days with minor seasonal differences in these traits. Among these entries one promising multiplier line performed well and was termed as TVM-6 with an average yield of 28.0 t/ha with 70 days maturity. Field screening for *anthracnose* and the bulb rot disease proved that the line TVM-6 had moderately resistant behavior to both the diseases in the field under complete absence of fungicide in both the locations. While others were susceptible or highly susceptible for the diseases tested, TVM-6 showed significantly higher response to vernalization in flowering in miner season while it flowered even without vernalization in majour season and produced more productive flowers than that of others. Therefore the line TVM-6 could be rated as a promising one with many desirable traits and this could be promoted for direct cultivation after adaptability testing and also could be effectively utilized as a promising breeding material for future cluster onion breeding programmes.

Keywords: Cluster onion, Anthracnose, Bulb rot

INTRODUCTION

The vast majority of cultivars of *Allium cepa.L.* Belongs to the "common onion group" (*Allium cepa var. Cepa*) and are usually referred to as "onions". The varieties belonging to multiplier onion and shallot subgroups are classified as "small onions". These two subgroups are the most important in *Aggregatum* group of *Allium cepa* L. in Sri Lanka (Sumanaratne *et al*., 2005). Both these type of Onion are believed to be brought by ancient traders from Tamil Nadu, especially to the northern Sri Lanka and later speared to the other parts of the country. (Arasakesry and Jehanthan, 2005). Red Onion is grown over an area about 4605 t / ha with the production of 55608 m t having an average yield of 12.08 t / ha (Agstat, 2014). Both shallots and multipliers are being widely cultivated in Sri Lanka. Information on systematic crop improvement research on red onion in Sri Lanka was not available until recent past except for some cultural practices including fertilizer recommendation and plant protection studies conducted earlier. In Sri Lanka, until recently local land races were being cultivated as a cash crop and maintained by storing bulbs under natural conditions. Studies by Sivalinghum and Kandhaiya, on shallot, type flowering strain was reported in 1967 where seedlings were transplanted from lines with around 80% flowering and seed yield of about 285kg/ha (seasonal research reports, Mahailluppallama, 1967). It was reported that in 1969 cluster onion varieties from Bangkok, Thailand, Philliphines, and also Vethalam were evaluated Sri Lanka. In 1970 and 80s'scientists in Field crop Research and Development Centre, Mahailuppallama (FCRDI) further conducted studies on red onion using both land races and introduction (Seasonal reports, 1974 *yala*, 76 *yala* and 78 *yala*).

As with other vegetable crops, onions are susceptible to numerous foliar, bulbs, and root fungal pathogens that reduce onion yield and quality. Out of them *Fusarium basal* rot (FBR, *Fusarium oxysporum*) is a root and bulb fungal disease of onions grown in temperate and subtropical regions. It invades the plant through roots and the basal stem plate via the soil. Anthracnose caused by *Colletotrichum gloeosporiodes* is also another serious fungal disease that affects onion in recent years. It damage the foliage by making concentric rings initially; later these rings coalesce to damage the entire foliage thereby leading to a heavy yield loss in the later part of the rainy season. It

spreads through air, soil and through seeds (Weeraatne et al., 2009). At present there is no resistant onion variety/ hybrid for these major fungal diseases in commercial cultivation through bulbs or using true seeds in Sri Lanka. Hence there is a need to breed a resistant or tolerant variety to increase the bulb production or to increase seed availability. Further very little knowledge on the resistant materials in cluster onion is available.

Studies were reinitiated in 2002 at the Agriculture Research Station, Thirunelvelly (ARS, TV) to expand the genetic pool, create diversity and to subject them in to possible selection and hybridization program by using through the identified promising breeding materials. As such this paper stems from a series of studies conducted for evaluate agronomic traits and screening against fungal diseases at ARS, TV, Jaffna and Regional Agriculture Research and Development centre Killinochchi (RARDC, Kilinochchi) during the last few years.

MATERIALS AND METHODS

The evaluation of locally grown popular land races in cluster onion was commenced in the year 2002. Filed experiments were conducted as observational trials in preliminary studies and replicated trials were continued after purification of the materials collected. In these experiments the names were given according to the places of collection and after identifying a few promising cultivars those were grouped in to two different classes as shallots and multipliers and then these were named serially as Thirunelvley shallot (TVS) for shallot types and Thirunelvly Multiplier (TVM) for multiplier types irrespective of the earlier identities. Then agronomic trials of TVM series (TVM-1 to TVM6) were conducted in different years (Table-3). Though several parameters were recorded in earlier studies for characterization (appendix-1), bulb number per plant, bulb weight per plant, days for maturity and the bulb yield were considered primarily in this paper. Raised beds of 3.75 m x 0.6 m and check basins of 1m x 1m were used for field evaluation in major (*maha)* and miner (y*ala*) season respectively. Randomized complete block design with three replications was used for all replicated trials. DOA recommendations were followed in all filed experiments. Trials were conducted in two different stations with various entries for disease screening and their details are given in the Table 5 and Table 6 as appearing in the text. The field was sprayed with a spore

suspension of *Colletroticum gloeosporiodes* ten days after planting, for screening of Anthracnose. For bulb rot screening, sick plot a technique was used (Priyantha *et al.,* 2009). Observations on disease severity for anthracnose and bulb rot were recorded on a 0-7 scale at 10 day intervals and disease severity index (DSI) was calculated as follows;

$$\text{DSI \%} = \frac{\text{Total sum of numerical ratings}}{\text{Maximum disease rating x no. of observations}} \times 100$$

This DSI data was analyzed by Kruskal wills non parametric analysismethod using SAS statistical computer software package version 14.

Using the following scale

Score	Damage
0	No symptoms,
1	-< 5 % leaf area affected
3	-6 – 25% leaf area affected,
5	-26 – 50 % leaf area affected,
7	-> 50% leaf area affected.

Same scale was used for bulb rot disease too as number of rotten bulbs at the field. Vernalization was done by keeping 100 viable bulbs wrapped in paper bags in cool room at 10+-1^{o}C for 21 days (Ramos and Ramos 1994).

Table-1 Detail of germplasm used for evaluation trial at ARS, TV

Serial No.	Accession number	Type	Name
	VMS- 104	Vethalam	-
	VLS- 104	Vallari	TVS-4
	VMS- 204	Vethalam	TVM- 5
	MVS- 104	Muri Vethalam	TVM-1
	MVS- 204	Muri Vethalam	-
	VLS- early- Vallari	Vallari	TVS-6
	VMS- 100% fl	Vethalam	-
	JVL 202-	Vallari	TVS-5
	JVM 302	Vethalam	TVM- 3
	JKV 102	Kal Vethalam	TVM- 4
	JMV 202	Muri Vethalam	TVM- 2
	JVV 102	Vadali Vethalam	VV
	JJI 102	Jaffna local	TVS-1
	JJI 202	Jaffna local	TVS-2
	JVI 102	Jaffna local	
	JJL 302	Jaffna local	TVS-3
	JVM 602	Vethalam	TVM-6

Table-2 Important agronomic trait of sixteen cluster onion land races at ARS,TV

SN	Entries	bulb weight	B/N	M/D	bulb weight	B/N	M/D	bulb weight	B/N	M/D	bulb weight	B/N	M/D
1	Sel 13	10.3 a	8 hi	79c	7.4 b	8c	66d	8.4 c	10fg	78c	9.3a.	10a	66d
2	VMS-100f	8.1 cd	7i	77e	9a	6e	65e	10.3a	8hi	79b	8.9b	10 a1	65e
3	JVM-302	6.3 fg	11fg	80ab	6.2cd	9b	62g	8.1cde	7i	77d	8.7b	10a	52g
4	JVM-402	6.8 ef	14c	81a	6.6 c.-	7d	76a	6.3gh	11fg	80a	8.2c	6d	76a
5	JKV-102	7.4 ef	12def	79d	4.5g	6e	63f	6.7 fg	14c	80a	7.2ef	8b	63f
6	JMV-102	5.4 fg	9gh	79d	6.6c	8c	63f	7.4ef	12def	79b	7.6b	8b	63f
7	JVV-102	7.5 ef	12ef	79d	5.6ef	9b	70b	6.3gh	9gh	79b	7.4de	8b	70.b
8	MVS-104	7.6 ed	15bc	81g	5.7def	9b	70b	7.4ef	12ef	79b	7.3def	8b	70b
9	JJL 102	5.8 g	17b	60h	3.3 I	10a	52h	7.6de	15bc	61fe	7.2ef	7c	52h
10	JJL-202	5.9 g	14cd	60h	3.8 h	9b	51j	5.8h	17b	60g	7.3ef	7c	51i
11	JKV-202	5.8g	21a	79d	5.8de	7d	70b	5.9h	14cd	80a	7.1f	7c	70b
12	VLS-104	8.3c	13cde	62f	3 I	9b	53f	5.8h	21a	69e	6.4g	6d	63f
13	JVM-502	6.1 fg	15c	79d	6.5c	9b	50j	8.3cd	13cde	62h	5.3h	6d	50j
14	JJL-302	9.4 b	13cde	52i	5.2e	8c	50j	6.2gh	15c	52i	5.1h	6d	50j
15	JVM-602	9.9 b	11fg	79d	6.7c	8c	69c	9.4b	13cde	79b	4i	6d	69c
16	JVM-702	8.7 b	8hi	79d	7.5b	8c	69c	10.3a	8gi	79b	4.2i	6d	69c
LSD (5%)		0.72	2.1	0.49	0.48	.34	0.24	0.72	2	.49	0.24	1	.24
CV (%)		5.8	9.9	04	5.05	2.5	04	5.81	9.9	04	2.1	9.5	04

BN- Number of bulbs / plant, MD- Maturity days, SN- Serial Number

Value in the same Colum followed by the same letter do not differ significantly ($P<0.05$)

RESULTS AND DISCUSSION

Agronomic traits of the cluster onion entries tested during these experiments are given in tables 2-6 serially**.** Various number of cluster onion entries were included in the series of experiments for characterization, evaluation and other agronomic studies. According to the availability seed materials Major traits such as days for Maturity, number of cluster per single plant, bulb size, and yield, had significant difference among the entries. Therefore twelve promising entries identified, were separated in to two major groups as shallots and multipliers having six in each groups (Table 2) and detail of multipliers are given in Table 3. As the aim of this paper is to focus the performances of a multiplier lines namely Thirunelvely multiplier No 6 (TVM-6) with high yielding ability, high flowering response and the favorable disease reactions. further, the discussions is also centralized towards the performance of this particular line in comparison with the other few entries in the same group in a series of experiments conducted in different locations. At the initial stages of the studies collected sixteen germplasm were purified and then these entries were studied under observation plots for two consecutive seasons to have the agronomic performances (Table 2). In these experiments shallots had more bulb number per cluster, less number of days to maturity, less single plant yield while the multipliers had reverse values for each of these parameters.TVM-6 fell under multiplier group had 156 and 55.5 grams, 12 and 6 bulbs per plant, 12.9 and 4.9 grams single bulbs, 79 and 68 numbers of days to maturity and 33.4 and 32.3 ton / ha yield in both *maha* and the *yala* seasons respectively.

Under replicated trials all these germplasm had significance difference among them and TVM-6 (JVM602) had the second highest rank in number of bulbs in two *maha* seasons and the third rank in the *yala* season. (Table 2) The bulb number per plant varied from 11 -13 in *maha* season. The days for maturity were higher in *maha* seasons and low in *yala* season .This is a common behavior of cluster onion having less maturity days in *yala* seasons. The yield performance of this TVM-6 was 26.83 and 28.2 t / ha with the maturity of 71 and 67 days in *maha* and *yala* seasons respectively in Jaffna condition.(Table 3) Yield of these entries varied significantly with TVM 6, giving with the average of 27.7 t / ha in both seasons. Days for maturity varied from 69days. a study conducted at ARS, TV in *maha* 2009/10 showed that only few germplasm were tolerant

to anthracnose and for severe moisture stress (Table 4) in this season. TVM6 (JVM601) gave more than 20 t/ha while all others gave comparatively lower yields. Therefore, TVM-6 has a potential of yielding more bulbs even under stress condition.

Table3. performances cluster onion entries at ARS, TV

	Maha		***Yala***	
Acc No.	**M/D**	**Yield (T/ha)**	**M/D**	**Yield (T/ha)**
TVM 1	76 ab	29.25 a	64 d	29.11 b
TVM 2	68 d	24.13 e	61 e	29.57 a
TVM 3	74 b	23.57 f	66 c	28.58 c
TVM 4	76 a	28.52 b	71 a	28.13 d
TVM 5	71 c	27.65 c	63 d	28.04 d
TVM 6	71 c	26.83 d	67 b	28.20 d
LSD	2.47	0.56	1.5	0.17

Value in the same Colum followed by the same letter do not differ significantly ($P<0.05$)

Screening for major fungal diseases

In a study conducted with twelve entries at ARS, TV in 2013/14, TVM-6 showed moderate resistance to Anhracnose disease (12.0 %) under fungicides spray free condition. (Table 5). The other entries TVS-3, TVS-6, Jaffna local and TV red also gave similar results. Resistance or tolerance of the shallots types are to be attributed to their short duration nature which normally escape from the heavy infection period of fungal disease.

Table 4. Yield data recorded from the tolerant individuals of the 20 lines tested at ARS, TV in *Maha* 2004/05

Serial number	Accession	Type	Average bulb(5 plant) weight (g)	Bulb number plant	Maturity days	Yield (t/h)
	Vms- 104	Vethalam	209.1	5	63	10.45
	Vls 104	Vallarai	280	8	53	14
	vms- 204	Vethalam	204	5	66	10.2
	mvs 104	Muri vethalam	163.8	4	66	8.1
	mvs- 204	Muri vethalam	172.6	5	64	8.6
	vlsearly	Vallarai	308	7	54	15.4
	vms 100f	Vethalam	145	5	63	7.2
	vms- 304	Vethalam	208	6	64	10.4
	vms 404	Vethalam	202	6	70	10.1
	JVL 202	Vallarai	133.91	4	68	6.6
	Jvm 202	Vethalam	111.3	4	71	5.5
	Jvm 302	Vethalam	161	5	67	8.05
	Jkv 102	Kal vethalam	121.8	4	66	6.7
	Jmv 202	Muri vethalm	170.1	5	68	8.5
	Jvv 102	Vaddali vallari	156.6	5	69	7.8
	jjl 102	Jaffna local	302.	7	56	15.1
	Jjl 202	Jaffna local	232.2	8	58	11.6
	Jvl 102	Jaffna local	303.2	8	58	15.1
	Jjl 302	Jaffna local	284.2	8	56	14.2
	Jvm 602	vethalam	429.2	6	58	21.4

The environment was conducive for high disease incidence at the latter part of the *maha* seasons with heavy mist prevail in this area. Among the multiplier the TVM-6 showed the lowest disease incidence and showed moderate resistance behavior for bulb rot with only 8.5 percentages of rotted bulbs. Further this had the lower bulb rot incidence among the multipliers while shallot as usual had very low values of the bulb rot incidence. This lower incidence of diseases in shallot types may be attributed to their short duration nature and the less rainfall received during the cropping period in this season at ARS, TV. On the other hand a study conducted at RARDC, KC with 30 entries of cluster onion for anthracnose screening in *maha* 2014/15 has revealed that of these thirty lines the one and only line showed the moderate resistance behavior (20%) was TVM-6 while the others

ranged from highly susceptible to moderately susceptible even with complete damage of foliage due to high incidence of anthracnose. Even with the unusually high rain fall with intermittent showers in this season which favored disease incidences TVM-6 had shown considerably commendable higher degree of tolerance to Anthracnose. (Table 6)

Flowering ability

Vernalization is a technique to initiate flowering in onion. Proper vernalization temperature of mother bulb stimulate early flowering and produces more flowers and thereby it increases true seed yield (Jonnes and Mann 1963). Study conducted at RARDC, KC has revealed that many germplasm has abilities to flower during *maha* season both under vernalaization and non vernalization condition (Figure 1,b). However in *yala* few tested entries flowered only with vernalaization with significance differences among them (Figure 1.a, Table 7). TVM-6 had the highest response for vernalization and gave 18.3 percent plants with flowering. Though all flowered in *maha* season except TVM-6 showed susceptibility or high susceptibility for both anthracnose and bulb rot disease. Thereby the TVM-6 produced more productive flowers (48%), produced more seeds and it was observed in our recent studies.

As per the results hither to discussed from the series of experiment since the year 2002 to date on agronomic performance, yield abilities, resistance to anthracnose and bulb rot disease of various cluster onion lines in different seasons and the locations the newly identified cluster onion line TVM-6 has high potential to be used as a new variety after conducting varietal adaptability trials or it could be used as a reliable breeding material for future cluster onion breeding programme by which we can incorporate the desirable traits such as high yielding abilities, resistance to major diseases and to increase flowering efficiency for true seeds production in Sri Lanka.

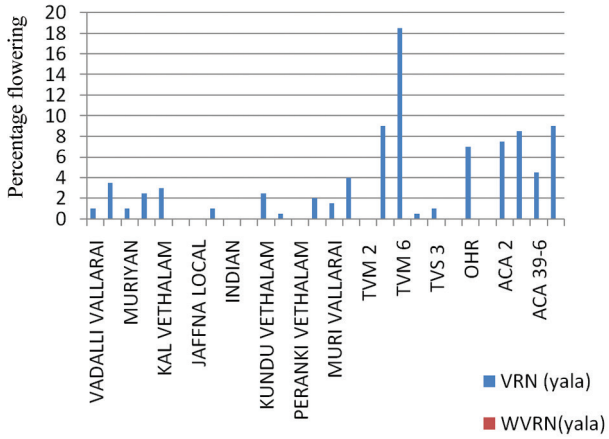

Figure.1.a Vernalazation response on flowering efficiency for 21 cluster onion lines at RARDC, KC (*yala* 2014)

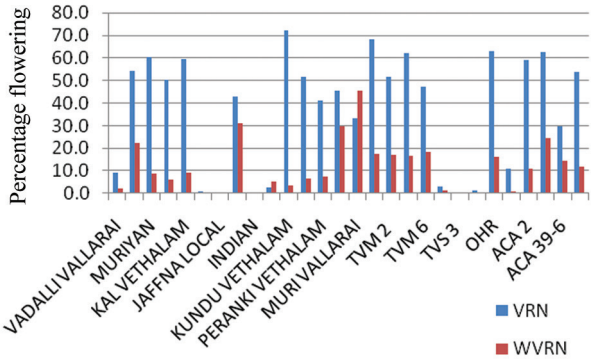

Figure. 1. B. Vernalazation response on flowering efficiency for 21 cluster onion lines at RARDC, KC (*maha* 2014/15)
VRN- Vernalaization , WVRN- Without *Vernalazation*

Table 5. Disease severity indices of 12 cluster onion lines for anthracnose, and bulb rot at ARS, Thinnavely in *maha* 2013.

Germplasam	Disease incidence			Rank
	Antracnos DSI	Rank	Bulb rot DSI	
TVM 1	35.2^{B}	S	74.7^{B}	HS
TVM 4	24.8^{C}	MS	20.5^{E}	MR
TVM 6	12.0^{DE}	MR	8.5^{G}	MR
PE VETHALAM	80.2^{A}	HS	82.0^{A}	HS
ARL 10	12.2^{DE}	MR	65.5^{C}	HS
OH R	22.5^{C}	MS	29.2^{D}	MS
OH 8	23.0^{C}	MS	23.2^{E}	MS
TRUE SEEDS	34.6^{B}	S	23.2^{E}	MS
TVS 3	12.1^{DE}	MR	13.2^{F}	MR
TVS 6	13.4^{D}	MR	0.25^{I}	R
Jaffna local	10.1^{E}	MR	0.53^{I}	R
Thinnavely Red	12.3^{DE}	MR	1.3^{H}	R
CV%	4.6		4.9	

0- HR, 1-5%- R, 6-20%- MR, 21-30%- MS, 31-50%- S, >50%- HS

Value in the same Colum followed by the same letter do not different significant ($P<0.05$)

Table 6. Disease severity indices of 30 cluster onion lines for Antracnos at RARDC, Kilinochchi in *maha* 2013.

S.No		DSI	Rank
	Vadali vallari	94.28^{C}	HS
	Vethalam	100.00^{A}	HS
	Muriyan	91.42^{D}	HS
	Vadali vethalam	71.42^{H}	HS
	Kal vathalam	74.28^{F}	HS
	True seeds	100.00^{A}	HS
	Jaffna local	91.42^{D}	HS
	Kundu vallari	21.42^{L}	MS
	Kal vathalam – 2	74.28^{F}	HS
	Pachchai muriyan	72.85^{G}	HS
	Kundu vethalam	94.28^{C}	HS
	Muri vethalam	94.28^{C}	HS
	Piranki vethalam	97.14^{B}	HS
	Poo vallari	94.28^{C}	HS
	Muri vallarai	91.42^{D}	HS
	TVM – 2	94.28^{C}	HS
	TVM – 4	85.71^{E}	HS
	TVM – 6	32.85^{K}	S
	TV Red	91.42^{D}	HS
	TVS- 6	97.14^{B}	HS
	OHR	74.28^{F}	HS
	OH_8	94.28^{C}	HS
	ACA – 2	100.00^{A}	HS
	ACA – 66	62.85^{J}	HS
	ACA – 39-6	97.14^{B}	HS
	ARL – 10	68.57^{I}	HS
	Vadali vallari – 2	62.85^{J}	HS
	TVM – 2(2)	94.28^{C}	HS
	TVM – 6(2)	20.00^{M}	MR
	TV Red (2)	97.14^{B}	HS

0-HR, 1-5%- R,
6-20%- MR, 21-30%- MS, 31-50%- S, >50%- HS

HR- Highly Recipient

R- Recipient

MR- Modernly Recipient

MS- Modernly Susceptible

S- Susceptible

HS- Highly Susceptible

Value in the same Colum followed by the same letter do not different significant ($P<0.05$)

Table 7 .Vernalization response of cluster onion lines for flowering Efficiency at RARDC.KC in *yala* 2014.

Land race	Without vernalization	With vernalization	
	***Maha* 2014/15**	***Yala* 2014**	***Maha* 2014/15**
ACA 2	11.0 hijk	7.5 bc	59 .0abcde
ACA 39-6	14.4 fghi	4.5 cde	29.7 h
ACA 66	24.7 cd	8.5 b	62.7 abc
ARL 10	11.7 ghij	9.0 b	53.7 bcdef
INDIAN	0 p	0 g	0 i
JAFFNA LOCAL	0 p	0 g	0 i
KAL VETHALAM	9.0 ijkl	3 .0efg	59.3 abcde
KUNDU VALLARAI	31.0 b	1 .0efg	43.0 efhg
KUNDU VETHALAM	3.3 lmnop	2.5 efg	72.0 a
LOCAL	0 p	0 g	0.7 i
MURI VALLARAI	45.7 a	1.5 efg	33.3 gh
MURI VETHALAM	6.7 jklmn	0.5 fg	51.3 cdef
MURIYAN	8.7 ijkl	1 .0efg	60.3 abcd
OH 8	0.7 op	0 g	10.7 i
OHR	16.3 fgh	7 .0bcd	63 .0abc
PACHCHAI MURIYAN	5.3 jklmno	0 g	2.7 i
PERANKI VETHALAM	7.3 jklm	0 g	41.0 fgh
POO VALLARAI	29.7 bc	2.0 efg	45.3 defgh
TV RED	1.3 nop	0.5 fg	3.0 i
TVM 1	17.7 ef	4 .0cdef	68.3a
TVM 2	17 .0efg	0 g	52.3 cdef
TVM 4	16.7 efgh	9 b	62.0 abc
TVM 6	18.3ef	18.5 a	47.3 cdefg
TVS 3	0 p	1.0 efg	0.3 i
TVS 6	0 p	0 g	1.3 i
VADALLI VALLARAI	2.3 mnop	1.0 efg	9.0 i
VADALLI VETHALAM	6 .0jklmno	2.5 efg	50.3 cdef
VETHALAM	22.3 ed	3.5 defg	54 .0bcdef
LSD	**5.7661**	**3.639**	**16.463**
CV %	**30.161**	**56.431**	**27.215**

Value in the same Colum followed by the same letter do not different significant (P<0.05)

CONCLUSION

The series of experiments conducted from the year 2002 to date concludes that it was able to characterize, evaluate and finding agronomic performances of more than thirty types of cluster onion land races: there were two major groups generated as shallots and multipliers. Among the multipliers one line was identified with average potential yield of 28 t/ha with 70 days maturity. This line was termed as TVM6. In addition to the yield performances this line also posses moderate resistance behavior for two major disease namely anthracnose caused by *chollottricum glioepiedus* and the bulb rot caused by *fusarium oxyisporum*. Since it showed more flowering thereby producing more seed in both m*aha* and *yala* seasons due to its disease resistance abilities and the vernalization responses.TVM-6 could be rated as an identified promising cluster onion line and a valuable breeding material with desirable traits which could be incorporated in to future cluster onion breeding programme successfully.

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