Research results on robusta coffee breeding in Vietnam

Viet Ha Phan*

Western Highlands Agriculture and Forestry Science Institute

Received 28 May 2017; accepted 25 Novenber 2017

Abstract:

In the research and development of coffee trees in Vietnam, particularly breeding is one of the most important activities and always prioritized by the Government. Since 1976, the Western Highlands Agriculture and Forestry Science Institute (WASI, former Coffee Research Institute), has invested a lot of efforts in selecting and creating new coffee varieties with good characteristics, namely high yield and big-sized beans, that have contributed to the enormous coffee development, especially to Robusta coffee. During 40 years, WASI has created and made them recognized by the Ministry of Agriculture and Rural Development with total 11 Robusta varieties. Of which, TR4, TR9, and TR11 are largely used in the cultivation in the Central Highlands, TR14 and TR15 are very promising to adapt to new challenge of climate change, and TRS1 is a good solution for quick seedling supplyies for the replanting program. These new varieties are highly recommended for the coffee development program till 2020 and in the coming years.

Keywords: ***breeding, coffee, high yield, new variety, Robusta, Vietnam.***

Classification number: ***3.1***

Background

During the last 40 years, a number of research projects have been done by the Western Highlands Agriculture and Forestry Science Institute, and it has selected 11 new Robusta clones for coffee replanting in the Central Highlands's provinces of Vietnam. These new varieties, especially the three normal ripening clones TR4, TR9, and TR11 and the two late ripening ones TR14 and TR15 have much higher yield and bean quality potentials compared to those of old cultivars [1]. The late ripening clones not only offer good characteristics such as high yield and good bean quality but also allow a delay of the first irrigation timing in the middle of dry season, thus we can save one irrigation application compared to other normal ripening clones.

Besides, with the high demand for coffee plantlets to serve replanting, the production of grafted plantlets is not sufficient due to the present capacity in Vietnam. Therefore, the research of good hybrid seeds taken from elite clones is necessary and by that way, TRS1 variety is selected. In fact, TRS1 is hybrid seeds collected from the seed producing garden growing selected clones: TR4, TR9, TR11, and TR12 [2]. Seedlings are better than clone production because of the production cost and propagation capacity. All Robusta varieties released by WASI are largely planted in the Central Highlands. They have shown a very good adaptation to the ecological condition of the region as well as the ability to give high yield and good quality beans [3].

Methodology

Materials

Robusta clones TR4, TR9, and TR11 were selected in Dak Lak's coffee growing areas. The late ripening clones TR14 and TR15 were selected from Indonesia's imported materials in 1996.

The synthesis variety TRS1 (seed) was created from open-pollinated one in seed producing garden growing TR4, TR9, TR11, and TR12 clones.

The TR4 clone was officially recognized as a national variety in 2006 by the Ministry of Agriculture and Rural Development (Decision No 1086 QĐ/BNN-KHCN on April 14, 2006); TR9 and TR11 in 2011 (Decision No 175/QĐ-TT-CCN on May 4, 2011); TRS1 in 2015 (Decision No 324/QĐ-TT-CCN, on November 5, 2015).

Research methodology

Clones or hybrids, after passing comparison trials and having initial evaluations, are reselected to go through

*Email: phanvietha@wasi.ac.vn

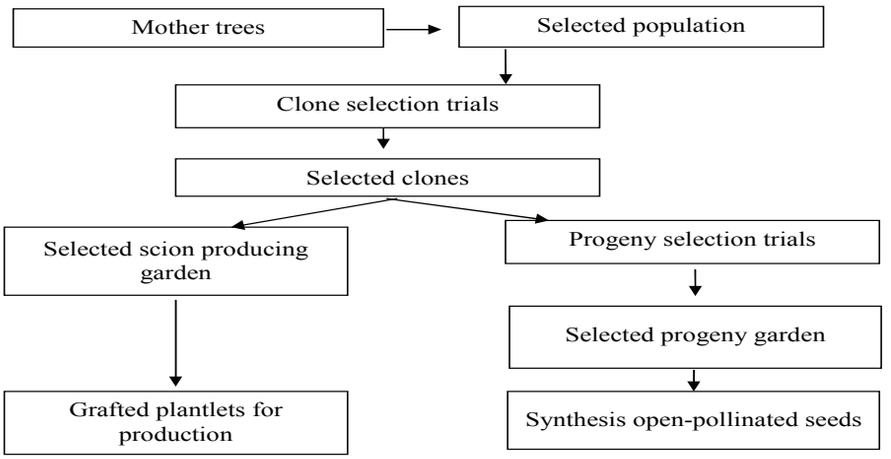

Fig. 1. Robusta varieties selection diagram

Table 1. Trial results of 3 robusta clones planted in Buon Ma Thuot - Dak Lak.

Clone	3 harvests' average yield (tons /ha)	Berry/green bean ratio	100 bean's weight (gr)	Bean's proportion remained on screen 16 (%)	Leaf rust index (%)
TR4	7.3	4.0	18.4	80.0	0.0
TR9	6.7	4.3	22.5	94.3	0.0
TR11	6.6	4.2	18.3	88.2	0.0

Fig. 2. TR4 trial in Dak Lak.

other trials in the Central Highlands provinces: Dak Lak, Gia Lai, Dak Nong, and Lam Dong (Fig. 1).

Clone comparison trials are RCBD with three blocks, 10-30 trees per block, total experimental area: 0.5-1.0 ha per province. The hybrid variety TRS1 is designed to compare with original varieties; experimental garden is the control one that is an average yield garden with the same care conditions and is grown at the same place and period.

Trial periods: TR4, TR11, and TR12 clone trials were implemented from 1999 to 2010; the late ripening clones TR14 and TR15 were from 2006 to 2015; the hybrid coffee TRS1 was from 2010 to 2015.

Monitoring and evaluation indicators

Growth: Stem diameter, tree height, number of primary branches, branch length, nodes per branch, and fruit bearing nodes, fruits per node.

Yield: An average yield of 3 harvests or more in the trial areas was compared with the average yield of mass planting with the same care conditions.

Green bean indicators: Samples are taken from each region with the number of 5-10 samples and for average two harvests. Each sample weighs 2.0 kg of berries. Analyzing and evaluating indicators: Berry/green bean ratio, Weight of 100 beans (g), proportion of beans remained on screen No. 16 (6.3 mm).

Leaf rust resistance ability on the field.

Data analysis and processing methods

Data is processed by biological statistics methods using EXCEL, SAS 9.2 software with F and LSD comparison test.

Results and discussions

Evaluation results on selecting 3 Robusta clones TR4, TR9, and TR11

As shown in Table 1, the three harvests' average yields of 3 clones are rather high in the condition of Dak Lak. Among them, TR4 clone shows dominant yield potential at 7.3 tons per ha (Fig. 2). TR9 and TR11 clones can also give high yields (more than 6.0 tons per ha). These three clones are the highest and most stable clones in term of yield potential compared to other six clones recognized by MARD at the same period.

Bean size and 100 beans' weight of these three clones are very impressive: 100 beans' weight of TR4 and TR11 clones is more than 18 grams. The TR9 clone especially has very big fruit size with 100 beans' weight which reaches 22.5 grams. In terms of bean proportion remained on the screen No.16, in average, these three clones get more than 80%, in which, TR9 gets 94.3%.

In Gia Lai province, these three clones are grown since 2005. The results on yields, bean qualities and leaf rust indexes are shown in Table 2.

Results in Table 3 show that the three harvests' average yields of TR4 and TR9 clones are almost the same (4.1-4.2 tons per ha), and the TR11 clone has lower yield. In general, Gia Lai's clones give quite high yields but a little lower than those in the condition of Dak Lak province. The bean size of these clones in Gia Lai is also big and they show high resistance to leaf rust disease.

When being planted in Lam Dong province, the three harvests' average yields of TR4 and TR11 clones are almost the same (4.8-5.2 tons per ha), while the TR9 clone has lower yield.

Especially in the conditions of Lam Dong province, these clones' bean size is very large with more than 85% of the beans at grade I (on screen No 16). The TR9 clone has 99.2% of grade I beans, and its 100 beans' weight reaches 29.6 grams.

Trials were implemented in the main coffee growing regions. Yield monitoring results show that in trial regions, these clones give yields varying from 3.3 to 4.0 tons per ha. These clones show good adaptation to the conditions in the Central Highlands (Table 4).

Evaluation results on selecting Robusta late ripening clones TR14 and TR15

Table 5 shows that in the three trial places, the Robusta late ripening clones give the four harvests' average yield higher than the control one. These clones can reach from 5.13 to 5.24 tons per ha while the TR6 only reaches 4.58 tons per ha. This difference is statistically significant.

Due to the interactions between regional condition and these late ripening clones, four harvests' average yield varies largely from 4.46 to 5.63 tons of green bean per ha, more than one ton per ha of difference. Especially in Dak Lak province, the TR14 clone gives the highest average yield (5.63 tons per ha) significantly compared with those in

Table 2. Trial results of 3 robusta clones planted in Iagrai - Gia Lai.

Clone	3 harvests' average yield (tons/ha)	Berry/green bean ratio	100 beans' weight (gr)	Bean proportion remained on screen 16 (%)	Leaf rust index (%)
TR4	4.2	4.2	15.3	63.2	0.0
TR9	4.1	4.5	17.0	75.0	0.0
TR11	3.7	4.4	15.7	65.0	0.0

Table 3. Trial results of 3 robusta clones planted in Bao Loc - Lam Dong.

Clone	3 harvests' average yield (tons/ha)	Berry/green bean ratio	100 beans' weight (gr)	Bean proportion remained on screen 16 (%)	Leaf rust index (%)
TR4	5.57	4.0	18.4	76.7	0.0
TR9	5.20	4.3	23.0	89.5	0.0
TR11	5.10	4.2	18.9	83.0	0.0

Table 4. Characteristics of 3 clones planted in trial regions.

Clone	3 harvests' average yield (tons/ha)	Berry/green bean ratio	100 beans' weight (gr)	Bean proportion remained on screen 16 (%)	Leaf rust index (%)
TR4	5.2	3.9	21.6	86.9	0.0
TR9	4.8	4.0	29.6	99.2	0.0
TR11	5.0	4.0	22.8	95.8	0.0

Table 5. Yields of Robusta late ripening clones (4 harvests' average yield).

Clone	Yield (tons/ha)			Average yield	Time from flowering to harvesting (months)
	Dak Lak	*Gia Lai*	*Lam Dong*		
TR14	5.63 a	5.15 cd	4.93 d	5.24 a	12
TR15	5.30 bc	5.19 bc	4.90 d	5.13 a	12
TR16	5.42 ab	5.15 cd	5.06 cd	5.21 a	10
TR6 (control)	4.67 e	4.46 e	4.46 e	4.58 b	11
Average	5.25 a	5.02 b	4.84 c	CV(%) = 3.24	

Fig. 3. The TR14 trial in Dak Lak.

Table 6. Bean quality and leaf rust resistance index of Robusta late ripening clones in trial places.

Place	Clone	100 beans' weight (gr)	Bean proportion remained on screen 16 (%)	Berry/green bean ratio	Leaf rust index (%)
Dak Lak	TR14	20.9	97.8	4.3	0
	TR15	24.9	98.1	4.2	0.1
	TR16	20.0	94.3	4.3	0
	TR6 (ck)	19.4	92.7	4.3	0
Gia Lai	TR14	20.5	95.4	4.2	0
	TR15	22.0	97.9	4.2	0
	TR16	19.1	93.2	4.3	0
	TR6 (ck)	18.4	91.5	4.4	0
Lam Dong	TR14	22.4	95.7	4.3	0
	TR15	23.5	96.3	4.3	0
	TR16	20.2	91.2	4.3	0
	TR6 (ck)	19.2	90.0	4.5	0

Table 7. Results on coffee cupping of Robusta late ripening clones in Buon Ma Thuot - Dak Lak.

Clone	Aroma	Flavor	Acidity	Body	Overall evaluation
TR14	Typical	Fair	Average	Good	Good
TR15	Typical	Fair	Average	Good	Good
TR16	Typical	Fair	Average	Good	Good
TR6 (ck)	Typical	Fair	Average	Good	Good

(Evaluated by: CAFECONTROL - Central Highlands Branch).

Gia Lai and Lam Dong provinces and with other clones in the three trial places (Fig. 3).

In all trial places, TR14, TR16, and TR6 (control) clones are not affected by leaf rust disease. The TR15 clone is affected slightly (0.1%) and only in Dak Lak but not in Gia Lai and Lam Dong.

Bean quality of these late ripening clones is rather good. The weight of 100 beans in all three regions reaches from 19.1 to 24.9 gram; much higher than the control - TR6 clone whose weight is from 18.4 to 19.4 gram. In trial regions, this weight reduces with this following order: Lam Dong > Dak Lak > Gia Lai. However, for the TR15, its weight in Dak Lak is higher than in Lam Dong. This can be explained by a better ability of the TR15 clone's dry matters in severe conditions compared to other clones (Table 6).

In the three trial regions, most of the Robusta late ripening clones have the proportion of beans on the screen No. 16 more than 90% and the low ratio of cherry/bean in the range of 4.2 to 4.5 (Table 6).

Besides the evaluation of green bean quality, results on coffee cupping in Table 7 show that: flavor and body of the samples are both good with typical aroma. The acidity is average, and overall, the cupping is evaluated at good quality. This evaluation shows that the dominant characteristics of these Robusta late ripening clones are bean quality and also the cup, one factor that is focused much nowadays.

According to the trial evaluation results on the adaptation of three Robusta late ripening clones in the main coffee growing areas of some Central Highlands provinces like Dak Lak, Dak Nong, and Lam Dong, it is clear that: These clones give very high yield (more than 4.5 tons per ha), especially in the conditions of Dak Lak (four harvests' average yield reaches 5.25 tons per ha) and especially with the TR14 clone (5.63 tons per ha) compared with other clones.

Table 8. Growth situation of the TRS1 variety in trial regions (18 months old).

Place	Diameter (mm)	Height (cm)	Number of primary branches	Branch length (cm)	Nodes/branch	Fruit bearing nodes	Fruits/node
Dak Lak	5.3	129.2 b	17.9 c	115.8	37.9 a	26.5 a	24.9
Gia Lai	4.9	142.0 a	22.7 ab	110.9	23.9 b	14.9 c	19.9
Dak Nong	5.8	144.0 a	19.8 bc	117.3	38.5 a	9.1 d	21.5
Lam Dong	4.9	145.7 a	24.5 a	110.3	24.5 b	22.2 b	21.7
CV (%)	9.9	4.2	7.6	5.1	9.9	9.6	8.5
LSD ($\alpha = 0.05$)	ns	11.7	3.2	ns	6.1	3.5	ns

ns: non-significant.

Table 9. Main characteristics of the TRS1 variety in trial regions.

Trial place	2 harvests' average yield (tons/ha)	100 beans' weight (gr)	Bean proportion remained on screen 16 (%)	Berry/ green bean ratio	Leaf rust index (%)
Dak Lak	4.05	20.8	90.9	4.6	5.4
Gia Lai	4.57	19.3	84.1	4.7	2.4
Dak Nong	4.43	18.2	85.7	4.5	12.4
Lam Dong	3.59	17.9	80.6	4.7	8.8
Average	4.31	19.1	85.3	4.6	7.2
Increase compared to the control	50.2	25.4	27.7	5.4	

In short, these clones are resistant to leaf rust disease and can give rather higher yield (more than 5 tons per ha) than the control TR6. The green bean quality is good with very big bean size, and they ripen from 15 to 25 days later than control clone.

Comparison and selection results of the Robusta hybrid variety TRS1

In Table 8, after 18 months, the research on the TRS1 variety's growth situation in the trial regions shows that: This variety can be adapted very well in all regions with an average stem diameter from 4.9 to 5.8 mm, the number of primary branches reaches from 17.9 to 24.5 pairs. The variation of all growth factors in trial zones is very low with CV under 10%.

The research results on trial models; the TRS1 variety in all regions shows that: the 2 harvests' average yield of TRS1 in the Central Highlands reaches 4.31 tons of green bean per ha; the average 100 beans' weight is approximately 19.1 grams; the proportion of grade I beans accounts for about 85.3% and the leaf rust disease index is about 7.2% (Table 9). In general, TRS1 shows a good adaptation with better yield and other factors than those which were commonly planted a long time ago in the Central Highlands.

Conclusions and recommendations

- New selected clones and varieties of Robusta coffee (TR9, TR11, TR14, TR15, and TRS1) show better yield, quality, etc. than all previous ones planted in the Central Highlands

- Using these new clones and varieties for replanting programs in Vietnam. Especially, TRS1 can be supplied in massive quantity for big programs and in large areas. TR14 and TR15 should be considered to be grown in regions with less irrigation water.

REFERENCES

[1] Nguyen Thi Thanh Mai, Dinh Thi Tieu Oanh, et al. (2016), "Selecting new Robusta high quality varieties for the Central Highlands", *Project final report for period 2011-2015*, Ministry of Agriculture and Rural Development.

[2] Dinh Thi Tieu Oanh, et al. (2015), *Results on selecting hybrid Robusta variety TRS1,* Report for new variety recognition 2015.

[3] Hoang Thanh Tiem, Che Thi Da, Dinh Thi Tieu Oanh, et al. (2011), "Selecting new varieties and research new cultivated practices for enhancing coffee quality for domestic use and export", *Project final report for period 2006-2010*, Ministry of Agriculture and Rural Development.