Hevea Research Platform in Partnership : Organization, Scientific Strategy, Research and Higher-Education Outputs

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HRPP : HISTORY AND ORGANIZATION

The "Hevea Research Platform in Partnership" (HRPP) was initiated by the researchers of the Rubber Research Project under the Thai-French Research Framework sponsored by the Commission on Higher Education of Thailand, the Thailand International Development Cooperation Agency, and the Government of the French Republic through the French Embassy to Thailand. This platform aims at strengthening excellence in the rubber commodity chain as well as academic networks and regional cooperation through the sharing of body of knowledge and technology transfer in this particular area.
On May 26th, 2008, the "Memorandum of Understanding creating the Hevea Research Platform in Partnership (HRPP) in Thailand" was officially signed by the following four core partners: Kasetsart University (KU), Prince of Songkla University (PSU), Department of Agriculture of Ministry of Agriculture and Cooperative (DOA), and CIRAD. Owing to the needs for further development in this field of research to achieve some acceleration of regional and international development, many universities and research institutions (6 from Thailand and 6 from France) became our Associated Members such as on the one hand Mahidol University, Khon Khaen University, Ubon Rachathani University, Mae Jo University, ORRAF and BIOTEC for the Thai side, and on the other hand Montpellier SupAgro, INRA, IRD, University of Montpellier II, Université Blaise Pascal of Clermont-Ferrand, Université du Maine of Le Mans for the French side.
At present, activities on this platform have been implemented by the HRPP members under supervision of a Steering and a Scientific Committee.

SCIENTIFIC STRATEGY

All the HRPP partners are gathered around a consensual common scientific project which aims to tackle the current challenges that Natural Rubber commodity chain faces. The originality of this platform is its integrated multidisciplinary approach which addresses varied issues from the Hevea seed to the rubber bale. Currently, experts in genetics, agronomy, plant physiology, eco-physiology, environmental science, biochemistry, rubber technology and socio economics conduct more than 20 joint research operations.
In mid-may 2011, scientists from all HRPP partners attended the HRPP annual seminar and workshops in Prince of Songkla University, Surat Thani campus. It was a great opportunity to conduct fruitful discussions in order to update this scientific strategy document.
From those discussions, **5 main issues faced by the Thai NR commodity chain** were identified:

1) Productivity of rubber plantations in Thailand

Continuous decrease of the size of Thai rubber smallholdings for the last two decades (now less than 2 ha, keeping on decreasing) has led to the general adoption of very intensive tapping systems by Thai rubber farmers. Implementation of tapping systems such as 2d/3, 3d/4 or 5d/6, associated with shortened tapping cuts (1/3S) are common. Improving the tapping productivity of smallholder plantations is a priority. Understanding the existing tapping systems and their evolution is necessary to suggest some possible improvements. However, the productivity of rubber plantations does not depend only on the tapping systems used by the farmers. Climate and soil conditions, management (particularly upkeeping before tree opening) and disease risks for a given plantation also determine its latex yield potential. Nowadays, knowledge is still insufficient to determine what are the optimal conditions for rubber cultivation in Thailand. Nevertheless, the possibility to increase productivity relies on the farmer's constraints and goals. Thus, it is important to understand the conditions for alternative tapping systems (Double Cut Alternative, Low Intensity Tapping Systems, Controlled Upward Tapping ……) to be adopted by the smallholders.

2) Global and local change impact on rubber production and sustainability in Thailand

South-East Asia, particularly Thailand, is the scene of substantial changes in connection with global changes that modify the biophysical environment as well as the economic and social environment of the countries. As one of the major agricultural sector in Thailand, involving about 10 millions of people directly or indirectly, the rubber sector is affected by these changes. Understanding the impacts of local climate changes and land use changes, in particular the extension of rubber cultivation towards the northeast and the north of the country where sub-optimal conditions prevail, on rubber plantations requires investigating the impacts of abiotic stresses (temperature and water stress, low soil fertility…) on rubber tree growth and productivity. In the same time, it is also necessary to understand how farmers perceive and react to the impacts of climate change on their plantations, as well as how they respond to the socio-economic change, and to help them to develop strategies to cope with these changes.

3) Environmental and social impact of natural rubber production and processing

Tree crop plantations provide renewable agricultural products. They are a forest-like ecosystem, where trees are covering the soil for long periods and therefore may contribute to the regulation of climate and the provision of supporting services as well. For example, rubber tree plantations (Thailand is the first producer of natural rubber) contribute to carbon sequestration and help avoiding deforestation through the use of renewable rubberwood. On the other hand, downstream, NR primary industry faces different environmental problems such as : the bad smell from storage area, dryer (STR), processing line and waste water treatment ponds (conc. latex) ; the need for improvement of waste management (low efficiency of treatment, lack of value added products from waste) ; the consumption of natural resources: fossil energy, water ; the lack of knowledge about carbon footprint for standardization ; the use of non-desirable chemical additives ; the need for greener processes. Besides individual assessment of each of these environmental impacts, a main issue is to develop an integrated assessment of the environmental footprint of the NR commodity chain based on the Life Cycle Assessment (LCA) methodology. This method should also include the assessment of social impacts of natural rubber production.

4) Performances of rubber planting material

In rubber such as in other crops, new varieties provide the farmers with an almost free-of-charge genetic contribution to profitability. Since more than 40 years, the varietal type used in rubber plantations is made of clones budded onto unselected seedlings that are used as rootstocks, with a predominant use of the clone RRIM600 in Thailand. Clonal diversification should prepare the move to more performing clones, promote a better capacity of adaptation, and reduce risks such as the possible onset of *Corynespora* disease

5) Non consistency of raw natural rubber

As for every natural product, it is difficult to produce raw NR with a constant quality all around the year. This is one of the major issues faced by NR factories in Thailand as their customers ask for more consistency in terms of properties. This problem gets crucial as the second transformation processes are more and more automated, which results in a lower ability to cope with non consistent raw material. On the contrary, synthetic counterparts of NR are much more constant. Fortunately, their over-all qualities are still lower than that of NR. So far, the international or national standards defining the ranges of acceptable properties are useful but not sufficient to predict the manufacturing behavior.

5 EXAMPLES OF RESEARCH OUTPUTS

1) GENMAP: generating tools for Marker-Assisted Selection

This research developed the first QTL-mapping approach on the domesticated population of the rubber tree (*Hevea brasiliensis*), based on a F1 family issued from two widely cultivated rubber varieties (RRIM600 x PB217). Genetic mapping (Prapan et al. 2004) was carried out by use of 427 PCR-based molecular genetic markers (microsatellites and AFLP). Phenotyping was carried out in East-Thailand on a site regularly affected by water stress. The measurements covered a period of 5 years of initial growth, followed by tapping periods during the rainy seasons of three successive years. The main studied traits were: growth, defoliation earliness, scoring of a die-back phenomenon in response to a drought, latex production and associated traits (latex diagnostic, plugging index), and the molar mass distributions of rubber chains measured by Steric Exclusion Chromatography.

Among a total of 49 detected QTLs, two major QTLs were detected repeatedly. The QTL g3-60 was associated with growth in girth of the trunk (or biomass), with the highest effect during the most favourable rainy periods of growth, and it explained up to 31 % of the phenotypic variance. Growth during tapping was mainly determined by two QTLs, g3-60 and g16-6. The QTL g16-6 was found associated with latex production (up to 66 % of the variance) and its related traits. Intensification of the tapping system generated an increase in inorganic phosphorus content in the latex, a decrease in sucrose content, a general reduction in the genetic variability of production traits, a reduction in the effect of the QTL g16-6, and a reduction in the number of QTLs detected for latex production. Meanwhile, the influence of trunk girth and of the QTL g3-60 on production was increased. Thus a change in the genetic determinism of the production with intensification was shown, probably due to the onset of a limiting factor which might be sucrose content in the latex. Only one other QTL (g16-46) was detected specifically for sucrose content traits. The cumulated effect of five QTLs explained 55 % of the variance of the percentage of short rubber chains which is indicative of the monomodal or bimodal distributions of the molar masses of native rubber. The QTL g10-68 was detected repeatedly for defoliation earliness. The QTL g18-94 was detected for the die-back index, in relation with rubber response to drought.
Based on these results, a new system of early selection is proposed, with Marker-Assisted Selection combining QTL genotyping and field phenotyping for increasing selection efficiency.

2) DCA: an innovative tapping system to improve the yield of Thai rubber plantations

In the context of the Thai rubber farms low tapping productivity, a new tapping strategy has been firstly implemented and tested from 2000 onwards at the Chachoengsao Rubber Research Centre (CRRC), then in different on-farm trials. This tapping system is called “Double Cut Alternative” (DCA). Its aim is to optimize high tapping frequencies by splitting tapping on two different cuts, tapped alternately, in order to increase the latex regeneration time in the bark. Over a period of 10 years, DCA increased cumulative rubber production by 9% compared to a single cut tapping system (S/2 d2) of equivalent intensity. The ability of the trees to produce more latex under DCA was related to the sucrose and inorganic phosphorus contents of the latex cells in each tapping cut. DCA produced metabolic activity more favourable to yield during the first 10 years of tapping. But DCA also resulted in higher TPD rates, a sign of a metabolic dysfunction of the productive bark. As DCA is a new tapping system, the evolution of the TPD tree stands in which DCA has been used must therefore be monitored. Further research is required to optimize the use of the DCA strategy. Such research will lead to new advances in our knowledge of the physiology of the rubber tree, mainly at the trunk scale.

3) Rubberflux: long-term monitoring of carbon and water fluxes in a rubber plantation

The Rubberflux experiment aims at providing a complete picture of the carbon and water cycles of a rubber plantation. This knowledge is essential to assess the carbon and water footprint of the rubber commodity chain in Thailand.
The experiment is situated at the Chachoengsao Rubber Research Station located in Phanom Sarakham district (13° 41’ N, 101°04’ E, 69 m above sea level, 140 km east of Bangkok). A 25m-high

“flux tower” have been set-up in 2007 to measure the flux of water and carbon at the interface between the canopy of the trees and the atmosphere using the eddy-covariance method. Beyond the evaluation of the fluxes, our purpose is to partition them among the different components of the plantation ecosystem (canopy, trunks, roots, understorey, soil) and the different functions (photosynthesis, respiration) in order to understand the factors controlling the carbon, water and energy budgets of the ecosystem.
Results on the carbon cycle show a carbon sequestration in tree biomass of about 15 tons/ha/year for a normal year in terms of climatic conditions. Nevertheless, some of the processes beyond this figure are very sensitive to the inter-annual variability in climate. Thus, our data show a 50% reduction of the C sequestration in tree biomass on a dry year (75% of the average annual rainfall).
The next steps of this operation will be focus on the development of a model to simulate the carbon and water cycles in a rubber plantation. Suc a model will be useful for the large scale assessment of carbon and water footprint of rubber plantations.

4) A joint biochemistry laboratory dedicated to the analysis of non-isoprene from natural rubber

Compared with its synthetic counterpart (synthetic poly(cis-1,4-isoprene)) which shows a consistent quality, natural rubber (NR) contains a relatively important non-polymer part (>5%) called non-isoprene. It is therefore assumed that non-consistency of NR properties may be related to its non-isoprene part constituted mainly by lipid and proteins.

In that framework, an ambitious study of non-isoprene of natural rubber was launched, starting with an investigation of lipid composition. Solvent extraction methodology development and chromatographic analysis protocol (TLC, GC FID, GC MS) were developed on different materials: fresh field latex, USS, RSS, rubber issued from maturated coagula (TSR, mini USS)

A clear picture of extractable lipid composition of rubber issued from several clones under different conditions is now availiable. It was confirmed that clonal origin is the most important factor of influence. Relations between the lipid composition (Phospho, glyco, neutral lipids, unsaponifiable, fatty acid composition), rubber structure (gel, molar mass distribution, averaged molar masses), and some physical and rheological properties (plasticity, plasticity retention index, viscosity, breakdown index, vulcanization behavior, storage hardening, …) of NR have been investigated. This biochemical approach will be pursued soon with studies on the second most important non-isoprene : the proteins.

The team of KU-CIRAD joint laboratory, essentially dedicated to lipid analysis is working in close collaboration with other partners using high and innovative technologies to characterize the structuration of natural rubber : Steric exclusion chromatography (SEC) or Asymmetric Flow Field Flow Fractionation (AsFFFF) coupled with Multi Angle Laser Light Scattering.

Indeed the understanding of rubber lack of consistency relies on the investigation of the dynamical interactions of the different elements that give to natural rubber its unique and very complex structure ensuring its unequalled properties.

5) Socio-economic analysis of tapping systems in Southern Thailand

This research focus on the existing tapping systems and aims at providing an accurate view and understanding of the underlying socio-economic logics that goes along different tapping practices observed in the field. Surveys with 118 rubber smallholders have been conducted in five districts of Songkhla province. From the result, tapping systems can be classified into two groups: 1) relatively low frequency tapping system such as 1/2S d/2 and 1/3S 2d/3 corresponding to RRIT recommendations and 2) high frequency tapping system such as 1/3S 3d/4, 1/2S 3d/4 and 1/2S 4d/5. High frequency tapping systems were the most popular; they are associated to low labor productivity and short productive year of plantation compared with lower frequency tapping systems. Several factors, both socio-economic and biophysical, have been identified as determining the choice of the tapping system. But some questions remains about the extent to which the land and labor constraints and their evolution as well as the search for high productivity of land and/or labor drives the behavior of the farmers for the management of their mature rubber plantations. The role of risk management as a driver for farmer's decision also needs to be addressed. In addition, since the implementation of the study (2007-08), the price of natural rubber has increased a lot and this raises the question of the response of the farmers to this market change, in particular how they adjust their tapping practices.

HIGHER EDUCATION OUTPUTS

A new Master Degree curriculum to be launched

Strengthen human capacities in natural rubber research and development project is part of the overall objective of the platform. During the workshop on High Education and Capacity Building held during the 1st Annual Seminar of HRPP (28 January 2009) it has been acted there was a need from the rubber sector for a complete HRD system with integrated knowledge in the whole value chain (from up-stream to down-stream). Following the workshop, it has been agreed to create a Working Group to build-up the curriculum in permanent connection with the rubber sector. The Working Group is presently composed of 2 Thai universities, namely Kasetsart University and Prince of Songkla University + Department of Agriculture (DOA), Montpellier SupAgro and Cirad which is acting as coordinator of the project. Since January 2009, during the different meetings of the Working Group, the 4 institutions agreed to jointly deliver a Master Degree on **"Natural Rubber Production, Technology and Management"**. The Working Group defined the training aims, the degree and the course structure of the curriculum.

Regarding the training aims of the curriculum, the Master is set up to develop and modernize the natural rubber production sector in sustainable and social-responsible ways by providing advanced level technical human resources in response to a demand from the rubber supply chain in Thailand and SE Asia.

This Master is intended to be international (courses will be given in English) and will be built in a first step as a joint degree between KU and PSU with the technical support of DOA, Montpellier SupAgro and Cirad.

The curriculum is planned to be achieved in 2 years, proposing 2 main options:

- Plan A (research oriented)
- Plan B (professional oriented)

The course structure will be a combination of theoretical classes, practical work, directed field-work, study visits, practical experience placements in a business, and courses will be located either at PSU or KU, or delivered through long distance teaching (video conference).

In order to officialize the creation of the Rubber Master Curriculum, and facilitate the accreditation of this new curriculum at the university level, a **Specific Memorandum of Understanding** has been signed on **February, 9th 2011** by the 5 partners (KU, PSU, DOA, SupAgro and Cirad). This curriculum is expected to be launched by June 2012.

More information on : http://hrpp.ku.ac.th