RISK ASSESSMENT REPORT

OF THE GENETIC MODIFICATION ADVISORY COMMITTEE (GMAC)

FOR

AN APPLICATION FOR APPROVAL FOR RELEASE OF TRANSGENIC RUBBER (*Hevea brasiliensis*) TREES FOR CONFINED FIELD TRIAL FOR RESEARCH AND DEVELOPMENT PURPOSE

NBB REF. NO: JBK(S) 602-1/1/17

APPLICANT: MALAYSIAN RUBBER BOARD

DATE: 16 JUNE 2015

I - Summary of Assessment Process

The Genetic Modification Advisory Committee, under the purview of the National Biosafety Board was given the dossier by the Department of Biosafety on 15 August 2014 for an application for approval for release of genetically modified rubber (*Hevea brasiliensis*) trees (hereafter referred to as "GM rubber trees") for confined field trial for research and development purpose. The application was filed by the Malaysian Rubber Board (hereafter referred to as "the applicant").

After conducting an initial review, GMAC requested for a scientific meeting with the applicant. The Principal Investigator (PI) of the proposed confined field trial, the Chairman of the Institutional Biosafety Committee (IBC Chairman) and the Biological Safety Officer (BSO) of the applicant attended the meeting and gave a scientific briefing on 7 October 2014. GMAC members also took the opportunity to obtain further clarification on certain details of the proposed field trial.

A public consultation for this application was conducted from 30 October 2014 to 28 November 2014 via advertisement in local newspapers. There were comments received from Third World Network (TWN) expressing concern on the use of human and animal (mouse) genes and CaMV 35S promoter in the GM rubber trees as well as the impact of the GM rubber trees on the soil, food webs and forest ecosystems over long periods. GMAC reviewed the input received and it was found that all the issues raised have been considered and taken into account in the risk assessment by GMAC.

Please refer to **Kertas LBK: 1/2/2015 - Lampiran IVA** for comments received from public consultation.

GMAC had 8 meetings pertaining to this application and prepared the Risk Assessment Report and Risk Assessment Matrix along with its recommended decision, for consideration by the National Biosafety Board.

II - Background of Application

This application is for approval for release of GM rubber (*Hevea brasiliensis*) trees for confined field trial for research and development purpose. The aim of the field trial is to evaluate the expression of the transgenes in the leaf and latex of the GM rubber (*Hevea brasiliensis*) trees at different stages of growth, under field conditions. According to the applicant, the transgene products are not intended to enter the food chain and no part of the GM rubber tree is intended for human use, other than verification of leaf and latex samples for expression of transgene and transgene product.

The confined field trial site which is 12 hectares of land was established in 2010, in Penawar, Kota Tinggi, Johor Darul Takzim. It belongs to the Malaysian Rubber Board and is managed by LGM Properties Corporation. The trial site is clearly marked to identify boundaries and the Global Positioning System (GPS) coordinates have been taken at all corners of the trail site

and submitted to the National Biosafety Board. The confined field trial site is fenced with link wires, 2 meters in height to prevent intrusion of the site. There is a minimum of 1.5km isolation from the boundary of the confined field trial site to the nearest rubber planting. A detailed map of the planting plots have been submitted, including identification of the guard/buffer row zones and locations of sexually compatible plants in the area. The applicant intends to plant an estimate of 10,000 GM rubber trees. Currently a total of 4,538 rubber trees have been planted, from which 1530 are GM rubber trees. The expected date for the field trial to end is approximately in 20 years' time, i.e. 2030-2032.

Information about the GM rubber trees (*H. brasiliensis*)

The recipient or parental plant is *H. brasiliensis* (rubber tree). The rubber tree has been genetically modified to harbour:

i) Glucuronidase (GUS) gene – a reporter gene encoding glucuronidase enzyme that hydrolyzes x-gluc - a colourless soluble substrate, into soluble blue coloured product. This serves as an indicator of transgene expression in the target tissue of the transformant. The donor organism for this gene is the *Streptococcus pneumoniae.*

ii) Recombinant antibody (scFv4715) specific to *Streptococcus gordonii* coat protein- Recombinant antibody (scFv4715) will bind to coat protein of *S. gordonii*, the causal agent of dental plaque/cavity. The donor organism for this is the *Mus musculus.*

iii) Human atrial natriuretic factor (HANF) gene - a gene that encodes for a blood peptide hormone that plays a role in lowering cardiac blood pressure, particularly during open heart surgery. The donor organism for this gene is the *Homo sapiens.*

iv) Human protamine 1 (HP1) gene – a gene that encodes a small peptide that has been shown to induce blood clotting. HP1 is a therapeutic protein which is commonly used to neutralize the anticoagulant effects of heparin during cardiovascular surgery. The donor organism for this gene is the *Homo sapiens.*

v) Neomycin phosphotransferase II gene – the nptII gene confers resistance to kanamycin and facilitates screening of transformed callus in growth media supplemented with kanamycin. The donor organism for this gene is the *Escherichia coli.*

The aim is to express and harvest the transgene product from the latex vessels of the GM rubber trees. Tapping of the GM rubber tree facilitates continual and non-destructive harvest of latex and the transgene product that is expressed therein. The genetic modifications are not expected to result in phenotypical changes to the rubber tree.

Details of the parent organism

The recipient or parental plant is *H. brasiliensis* (rubber tree). Although *H. brasiliensis* originated from the Amazon basin in South America, the plant has been adopted for cultivation in many countries in the tropical region, including Malaysia. Rubber elastomer and wood obtained from the tree serve as feedstock for a wide range of downstream applications.

H. brasiliensis is a monoecious flowering plant. The inflorescence is a panicle of separate staminate and pistillate flowers borne in the axils of basal leaves of new shoots. Pistillate flowers are terminal to the central stem and other major branches of the inflorescence. Smaller and more numerous staminate flowers make up the rest. Both flowers are shortly stalked and

scented. Neither flower has petals but rather five triangular lobes. Staminate flowers have two rings of five stamens each borne on a stalk. Pistillate flowers have a compound ovary with three locules topped by three sticky, sessile stigmas. Within an inflorescence, a few staminate flowers open first and fall off after one day. Pistillate flowers then open for a period of three to five days after which the rest of the staminate flowers open. This mechanism ensures a high degree of cross-pollination. Pollination occurs primarily through insects, mainly bees, midges and thrips. Fertilization occurs within 24 hours after pollination. Unfertilized pistillate flowers quickly wither and die. There appears to be no evidence of self-incompatibility although cross-pollination usually results in better fruit set.

In Malaysia, flowering of *H. brasiliensis* occurs in February to April and (a lesser flowering) in September and October. After pollination, fruits mature in 6-7 months and dehisce explosively, scattering seeds in the vicinity of the mother trees. Isozyme marker studies revealed that pollen can be disseminated as far as 1.1 km from the mother plant in plantations.

Vegetative propagation is a common practice in rubber cultivation where scions of plants are grafted onto selected root-stocks, creating identical copies of the mother plant. This technique opens up the potential to generate unlimited copies of a single plant for rubber cultivation.

There are no known wild relative of the genus Hevea in Malaysia. Other than *H. brasiliensis* there are no other species that are cultivated in Malaysia.

The rubber tree (*H. brasiliensis)* has no known toxic effects on human, animal and other organisms. Sporadic cases of allergy to latex products have been reported.

H. brasiliensis trees cultivated primarily for rubber require periodical commercial fertilizer application throughout the productive phase i.e. twenty years, while trees cultivated for wood are maintained as forest plantation until they are felled after fifteen years.

Details of the donor organisms

Characteristics of *Streptococcus pneumonia*

Streptococcus pneumoniae, or pneumococcus, are encapsulated, Gram-positive bacteria that are usually found in pairs (diplococcic) but can also be found singly and in short chains. Individual bacteria are between 0.5 and 1.25 micrometers in diameter. S. *pneumonia* are alpha-hemolytic, facultative anaerobic member of the genus *Streptococcus*. They do not form spores and are non-motile, though they sometimes have pili used for adherence. A significant human pathogenic bacterium*, S. pneumoniae* are normally found in the upper respiratory tract, including the throat and nasal passages and was recognized as a major cause of pneumonia in the late 19th century, making it the subject of many humoral immunity studies.

Characteristics of *Mus musculus*

The house mouse (*Mus musculus*) is a small mammal of the order Rodentia, characteristically having a pointed snout, small rounded ears, and a long naked or almost hairless tail. Although a wild animal, it lives mainly in association with humans and has been domesticated as a pet and as a laboratory mouse. It is the most commonly used mammalian research model and often used for research in genetics, medicine and other scientific disciplines. This is due to its

close relationship and high homology with humans as it shares more genes, anatomy and physiology with humans. Many laboratory strains of mice have been inbred to be genetically identical, making it easier to see the effects of an experimental treatment or change in a single gene. House mice have an adult body length (nose to base of tail) of 7.5–10 cm and a tail length of 5–10 cm. The weight is typically 10–25 grams.

Characteristics of *Homo sapiens*

Humans *(Homo sapiens)* are a eukaryotic species belonging to the primate group and share characteristics with chimpanzees, gorillas, and orangutans (the great apes), as well as other apes. By present estimates, humans have approximately 20,000–25,000 genes whereby functional human DNA is approximately 98.4% identical to that of chimpanzees when comparing single nucleotide polymorphisms. Therefore, the closest living relatives of humans are gorillas and chimpanzees, as they share a common ancestor.

Unlike most other primates, humans are capable of fully bipedal locomotion, thus leaving their arms available for manipulating objects using their hands, aided especially by opposable thumbs. Anatomically modern-appearing humans originated in Africa about 250,000 years ago, reaching full behavioral modernity around 50,000 years ago. Humans are currently widespread in the world and inhibit every continent on Earth, except Antarctica

Humans are omnivorous and considered super predators as they have few natural predators and often sit at or near the top of the food chain in regional ecosystems.

Characteristics of *Escherichia coli*

Escherichia coli (commonly abbreviated *E. coli)* is a Gram-negative, non-spore forming, rod shaped bacterium of the genus *Escherichia* that is commonly found in the lower intestine of warm-blooded organisms*. E. coli* is a facultative anaerobe that ferments simple sugars such as glucose to form lactic, acetic, and formic acids. Most *E. coli* strains are harmless, but some serotypes can cause serious food poisoning in their hosts, and are occasionally responsible for product recalls due to food contamination. The harmless strains are part of the normal flora of the gut, and can benefit their hosts by producing vitamin K2 and preventing colonization of the intestine with pathogenic bacteria. *E. coli* is one of the most widely studied prokaryotic model organism as it can be grown easily and inexpensively in the lab. Because of its long history of lab culture and easy manipulation, *E. coli* plays an important role in the field of biotechnology and microbiology especially in the production of recombinant proteins. Modified *E. coli* cells have been used in vaccine development, bioremediation, production of biofuels and production of immobilized enzymes.

Modification method

Large scale cultures of *Agrobacterium tumefaciens* GV2260 that contained the gene constructs were grown on LB broth containing kanamycin (50 µg/ml) at 28˚C until stationary phase. The OD_{600nm} of the bacterial culture was adjusted to circa 0.6 using culture initiation (CI) media. *H. brasiliensis* GL1 anther callus was initiated from the anther walls (tapetum cells) in MS (ID)Z media. The callus tissue was then co-cultivated with *A. tumefaciens* GV2260 harbouring gene of interest to allow infection and insertion of the desired transgene into the

rubber genome as described elsewhere. After co-cultivation, the callus tissue was transferred to fresh initiation medium containing cefotaxime and ticarcillin, to prevent overgrowth of *Agrobacterium*, while kanamycin in the selection media ensures growth of putative transformed callus. The plates were incubated in the dark at 25˚C for 14 days (first selection); the callus cultures were subjected to several rounds of selections prior to embryogenesis and subsequent regeneration of plantlets. The plant expression vectors used for the different genes are pBIN19 (for GUS), pGPTV-Kan (for scFv4715), pGPTV-Kan (for HANF) and pGPTV-Kan (for HP1). Expression of scFv4715 in the original pGPTV-Kan is driven by CaMV 35S promoter while that of HANF and HP1 is driven by hevein promoter**.**

Characterization of the modification

The transformed plants placed in netted house were tested for transgene expression and the results show that all the transgenes were stable in the vegetative generation. The levels of expression of the GUS protein and scFv4715 in *Hevea* transformants were determined using ELISA. The presence of HANF transcript was shown using RT-PCR technique. HANF protein was detected in leaf tissue by SDS-PAGE followed by Western blot analysis using an antibody specific to HANF. The presence of nptII gene is detected by genomic PCR using specific primers and separation on agarose gel.

III - Risk Assessment and Risk Management Plan

GMAC evaluated the application with reference to the following documents:

(i) Roadmap for Risk Assessment of Living Modified Organisms, (according to Annex III of the Cartagena Protocol on Biosafety produced by the *Ad Hoc* Technical Expert Group (AHTEG) on Risk Assessment and Risk Management of the Convention on Biological Diversity).

(ii) The risk assessment and risk management plan submitted by the applicant.

GMAC took cognizance of the following as suggested within the AHTEG guidelines:

(i) That the risk assessment exercise be specific to the details of this particular application;

(ii) That the risk assessment exercise be specific to the receiving environment in question; and

(iii) That any risk identified be compared against that posed by the unmodified organism.

A Risk Matrix was prepared based on an assessment mechanism developed by Office of the Gene Technology Regulator, Australia (OGTR, 2005). In applying this matrix, GMAC identified potential hazards, and then added a value/rank for the likelihood of each hazard as well as its consequences. The likelihood of each hazard occurring was evaluated qualitatively on a scale of 1 to 4, with 1 for ‘highly unlikely’, and 4 for ‘highly likely’.

The consequences of each hazard, if it were to occur, were then evaluated on a scale of 1 to 4, with 1 for 'marginal' and 4 to denote a 'major consequence'. A value was finally assigned for the overall risk from the identified potential hazard. The general formula: Overall Risk = Likelihood x Consequence was employed. GMAC also proposed risk management strategies for potential hazards, where appropriate. This methodology of assessment follows the procedure of Risk Assessment in Annex III of the Cartagena Protocol on Biosafety.

The Risk Assessment was conducted over a series of 8 meetings as well as series of emails related to the assessment of this application. To start with, the possible pathways to risk/hazard arising from release of the GM rubber trees were identified and listed. The potential hazards were identified in three main areas:

(i) **Effects on human health**

Issues pertaining to acute toxicity of the novel proteins, potential allergenicity, mutagenic/teratogenic/carcinogenic effects, reproductive toxicity, potential transfer of antibiotic resistance genes in the digestive tract, the pathogenic potential of donor microorganisms, nutritional equivalence and altering/interference of metabolic pathways were examined.

(ii) **Effects on animal health**

Issues pertaining to allergenicity, acute and chronic toxicity, anti-nutritional properties, compromised nutritional content and horizontal gene transfer were examined.

(iii) **Effects on the environment**

Issues pertaining to enhanced fitness and/or invasiveness, unintentional release and planting, horizontal gene transfer to soil microorganisms/non GM trees/related species and altering/interference of metabolic pathways were examined.

Based on the above, a final list of 20 potential hazards was identified with 17 of these hazards rated as having an Overall Risk of 1 or "negligible", 2 hazards with an Overall Risk of 2 (with the risk estimate being "low") and 1 hazard with an Overall Risk of 3 with a "moderate" risk estimate (please refer to the **Lampiran IIB/*Risk Matrix*** for details).

GMAC also took extra caution and further discussed pre-emptive mitigation procedures for hazards where the Overall Risk was estimated to be above the minimal, and also for a few hazards that required further evaluation and data acquisition. Some of these risks are expected to be managed effectively with the risk management strategies proposed (please refer to section IV of this document).

GMAC had conducted a thorough assessment to include the risk posed to human and animal health and effects to the environment. Pertinent potential hazards are highlighted below along with the appropriate management strategies:

(i) Expression of foreign genes leads to production of toxin and/or allergens in the pollen and latex.

The scFv4175, HANF and HP1 recombinant proteins are not expected to be allergenic or toxic but there is a small likelihood that when expressed on the pollen or in the latex may result in allergenicity and cause toxic/allergic reactions in human workers handling and tapping the latex when exposed to the latex of the GM rubber trees or its pollen. This requires risk mitigation and strict adherence to Standard Operating Procedures (SOPs) on the use of personal protection equipment to avoid exposure to latex. Access to the GM trees should be limited to authorised workers only. Proper training should be given to workers who will be handling the GM rubber trees and latex. Continuous monitoring for adverse effects on humans should be carried out.

(ii) Transfer of transgenes sequences to non-GM rubber trees through pollen.

Hevea brasilliensis is a monoecious plant and has a high outcrossing rate. Pollination is by insects and as the distance of the nearest rubber tree plantation is 1.5 km away, it is not within the flying range of pollinating insects, making the transfer of transgenes to non- GM rubber trees through insects unlikely. However, transfer is possible by other animals such as monkeys and birds. This will result in severe consequences if expression of the transgenes can result in toxicity/allergenicity and /or weediness. A buffer zone encircling the confined field trial site must be established and sampling for volunteers in neighbouring plantation must be conducted. The applicant must also have a contingency plan in place - in case cross pollination of GM and non-GM rubber trees should occur.

(iii) Unintentional release of GM rubber trees into the environment due to explosive nature of fruit dehiscence.

Unintentional release of viable GM material into the environment can happen due to the explosive nature of fruit dehiscence of mature rubber trees. As a precautionary measure, regular inspection should be carried out to ensure that no volunteers are found within and in the vicinity of the trial site. Any volunteers found must be destroyed.

(iv) Unintentional release of GM rubber trees into the environment by animals.

Removal of viable GM material by animals such as monkeys, rats, etc. will result in release of GM rubber trees into the environment. To mitigate this risk, the IBC of LGM must ensure that the measures to prevent transfer of seeds from GM rubber trees are in place. This includes regular checking of the fence to ensure its integrity at all times as well as implementing appropriate pest control measures.

IV - Proposed Terms and Conditions for Certificate of Approval

Based on the 20 potential hazards identified and assessed, GMAC has drawn up the following terms and conditions to be included in the certificate of approval for the release of this product. In addition, the applicant is also required to follow the guidelines as specified in the NBB document *Biosafety Guidelines: Confined Field Trials of Living Modified Plants in Malaysia* (Department of Biosafety, 2012).

Part A: Actions to be taken and reported to the National Biosafety Board prior to the start of the field trial

(i) A consent letter to conduct the confined field trial from the Local Council for the district where the site is located shall be provided.

(ii) Proper signage shall be present at the trial site informing of the presence of GM rubber trees as according to the Confined Field Trial Guidelines. Access to the confined field trial site shall be limited to authorised personnel only.

(iii) Appropriate training shall be given to workers who will be handling the GM rubber trees and latex.

(iv) Medical surveillance plan for all the staff, including contract workers, handling latex and working in the confined field trial site shall be developed.

(v) Pest and animal control measures shall be in place at the confined field trial site.

(vi) The owner of the plot of land on which the confined field trial site is situated (LGM) must consent, in writing, to a post-trial land use restriction period of 2 years.

(vii) An Emergency Response Plan shall be prepared and approved by GMAC to handle possibility of cross pollination of GM and non-GM rubber trees.

Part B: Actions to be taken and reported to the National Biosafety Board during the field trial

(i) The approved Standard Operating Procedures (SOPs) for transportation of all GM rubber trees and materials from the greenhouse to the confined field trial site shall be adhered to. Records shall be kept for all GM rubber trees transported to the confined field trial site.

(ii) An isolation zone shall be established, whereby the confined field trial site must be separated by a distance of at least 1100 meters from other rubber trees or sexually compatible species on all sides. This isolation zone shall be monitored regularly and maintained free of volunteers of the rubber trees or sexually compatible species. All such volunteers shall be removed and destroyed.

(iii) A buffer zone of 15 meters immediately surrounding the confined trial site shall be established. Regular bi-monthly inspection shall be carried out to ensure that there are no volunteers in the vicinity of the buffer zone. Any volunteers found shall be collected and destroyed. A record of this inspection exercise and of the numbers

of volunteers destroyed shall be maintained. The buffer zone is subjected to post-trial land use restrictions (see Part C below), and these inspections shall be extended for a period of two (2) years after the trial has ended.

(iv) If a breach of the isolation zone and buffer zone should occur, the National Biosafety Board shall be informed immediately.

(v) Routine sampling and random testing of volunteers in neighboring or nearby rubber plantations shall be conducted. If outcrossing events are detected, the National Biosafety Board shall be informed immediately. Such sampling and testing shall be extended for a period of 2 years after the confined field trial has ended.

(vi) The Emergency Response Plan approved by GMAC must be implemented if there is a cross pollination of GM and non-GM rubber trees.

(vii) Records of all plant materials, seeds, etc. that are removed from the trial site for storage or analysis off-site shall be kept. The SOPs for transporting such materials shall be strictly adhered to.

(viii) Since there is potential toxicity and allergenicity, bioinformatics studies to identify any allergenic motifs in the sequence of the expressed recombinant proteins shall be carried out.

(ix) Allergenicity test with the latex from each of the three types of GM rubber trees shall be conducted.

(x) Appropriate and continuous training shall be provided to workers who will be handling the GM rubber trees and latex.

(xi) Medical surveillance for all the staff, including contract workers, handling latex and working in the confined field trial site shall be conducted.

(xii) Pest and animal control measures shall be implemented. Regular inspection of the fence shall be carried out to ensure its integrity at all times.

(xiii) The Biosafety related approved SOPs that have been approved under this application shall be strictly adhered to and personal protection equipment shall be used to avoid exposure to latex.

(xiv) No changes shall be made to the Biosafety related SOPs that have been approved under this application. Any changes proposed shall be submitted to and approved by GMAC.

(xv) Additional conditions may be imposed based on a monitoring visit by GMAC and these conditions shall be complied with.

(xvi) An annual report shall be submitted through LGM Institutional Biosafety Committee on the types and numbers of GM trees planted, removed, or destroyed. An updated map of the planting shall be included with the annual report.

Part C: Actions to be taken and reported to the National Biosafety Board at termination of the field trial

(i) At the termination of the field trial, all residual plant materials in the confined field trial site shall be rendered non-viable using methods approved by GMAC. The confined field trial site and the buffer zone are subjected to post-trial land use restrictions for a period of two (2) years. Part or all of the isolation zone, may also

be subjected to similar restrictions, if a breach has occurred during the confined field trial.

(ii) During this 2-year period, the confined field trial site, buffer zone and other affected areas shall not be planted with plants of the same species (GM or non-GM) without prior approval from the National Biosafety Board. The confined field trial site and buffer zone shall be continuously monitored for growth of volunteers, which shall be collected and destroyed. Proper records of these post-trial activities shall be maintained and submit a report shall be submitted to the National Biosafety Board upon the expiry of the post-trial period.

V - Other Regulatory Considerations

There are no other regulatory considerations.

VI - Identification of Issues to be Addressed for Future Releases

One additional issue has been identified that would be important during the assessment of an application for a larger scale or commercial release of GM rubber trees, which is:

(i) Since there is no data on toxicity and allergenicity to human and animal, it is recommended that studies addressing these issues should be initiated.

VII – Conclusion and Recommendation

GMAC has conducted a thorough evaluation of the application for approval for release of GM rubber (*Hevea brasiliensis*) trees for confined field trial for research and development purpose and has determined that the confined field trial does not endanger biological diversity or human, animal and plant health. GMAC recommends that the proposed application for confined field trial be **APPROVED WITH TERMS AND CONDITIONS** as listed in section IV (Proposed Terms and Conditions for Certificate of Approval). GMAC also recommends that Section VI (Identification of Issues to be Addressed for Future Releases) be forwarded to the applicant for further reference.

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