



Review Article

New Paradigm on Plant Quarantine System for Protection of Biological Diversity in Indonesia

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ABSTRACT

Plant quarantine system becomes an important pillar in the protection of biological diversities from the threat of plant pests and diseases. The implementation of plant quarantine system currently covers prevention of spread of quarantine pests, food safety, food quality, genetic resources and bio-agents, as well as invasive alien species and genetically modified organism. During 2014 to 2018, a total of 232 frequency intercepted of quarantine pests of viruses, bacteria, fungi, nematodes, insects, and weeds have been detected. These pests associated with plant materials from various countries in Asia, Europe, the United States, Australia and Africa that may potentially threaten biological diversities when dispersed within Indonesian territory. Implementation of risk analysis and appropriate level of protection consideration can be clustered in to pre-border, at-border, and post-border activities in order to mitigate the risk of quarantine pests and biosafety monitoring into Indonesian territory. Utilizing advances in pest detection technology in the industrial era 4.0 could provide benefits in the agricultural sectors. Various detection technologies using drones and bio-sensors have contributed in the field of plant protection, especially as pest detection and monitoring tools in the field. Furthermore, the establishment of proficiency certification agency for plant quarantine systems may contribute efficient and effective operations in the near future.

Keywords: biological diversity; Indonesia; quarantine system

INTRODUCTION

The agricultural sector is still an important part of Indonesia's economic development; this is indicated by its contribution to gross domestic product (GDP). Statistical data showed that in 2018, agricultural exports reached 42.5 million tons by total value of IDR 1,370 trillion (Agricultural Quarantine Agency, 2019; Ministry of Agriculture, 2019). In addition, agricultural sector is the main producer of people's food needs. The higher agricultural production and productivity, the better a country's level of food security. Threats to food production and supply caused by pests can cause food insecurity. The entry of pests and diseases can

be caused by trading activities of agricultural products from abroad through trade in plant and plant products might be declined their quantity and quality.

Past experience has provided valuable lessons with the entry and spread of exotic pests such as coffee leaf rust disease (*Hemileia vastatrix* B. et Br.) in coffee plants, clove leaf pox (*Exobasidium vexans*), and coffee powder pests (*Hypothenemus hampei* Ferr.) (Dano, 1980). Another example of a disease outbreak caused by papaya rings spot *Potyvirus* (PRSV)P on papaya growing areas in North Sumatra has been reported (Agricultural Quarantine Agency, 2013). The PRSV has been categorized as A2 Quarantine pests (Minister of Agriculture, 2020). These pests can reduce crop production and increased control costs.

The plant quarantine system plays an important role in the trade of agricultural commodities and plant health. Sanitary and Phytosanitary (SPS) measures are based on scientific principles and risk assessment to protect agricultural industry from the threat of pests. Implementation of the SPS measures as an effort to prevent pests from entering and spreading in to Indonesian territory, through plant quarantine system (Agricultural Quarantine Agency, 2002).

Various issues regarding spread of pests, food safety, biosafety and the environment have not been able to be implemented optimally. To overcome various constrains in the protection of biological diversity, the Government has issued Law Number 21 of 2019 concerning Animal, Fish and Plant Quarantine (Agricultural Quarantine Agency, 2019). With the issuance of this law, perhaps could answer the challenges of protecting biological diversities in Indonesia

THREAT QUARANTINE PESTS ON BIOLOGICAL DIVERSITY

The International Plant Protection Convention (IPPC) has established provisions such as standards, guidelines, and recommendations that can be used by a country in protecting plant biological diversities from the threat of pests that can be carried out in international trade (International Plant Protection Convention, 2006). The commission also regulates

rights and obligations of each member country, dispute resolution cooperation, and technical standard commissions. The commission's contribution to the protection of biological diversity has a positive impact on protecting farmers from economic losses due to pest incursion, the environment from losing species diversity, and ecosystems (Suharto *et al.*, 2006).

The Ministry of Agriculture (2020) published 830 species of quarantine pests, consists of insects, fungi, nematodes, bacteria, viruses, mollicutes, weeds, mites, snail and slug that potentially enter and spread to Indonesian territory (Table 1). These quarantine pests belong to insects (33%), fungi (18.8%), nematodes (9%), and the lowest was mollicutes (2%). The spread of pests between countries has reached alarming levels and threatens food security and the preservation of biological diversities. For example, the spread of an emerging Armyworm (*Spodoptera frugiperda* E.F. Smith) in corn growing areas (Center for Plant Quarantine, 2019), may become an alarming level if no massive control are taken. However, the most troublesome of A1 Quarantine pests of grain, Khapra beetle (*Trogoderma granarium* Evert) has not been found yet in Indonesia (Wuryaningsih *et al.*, 2009). Another species of quarantine pests, such as cyst nematode (*Globodera rostochiensis* Wollenweber) in potato growing areas (Center for Plant Quarantine, 2005,

Table 1. List of quarantine pests that should be prevented in to the Indonesia territory

Group of Quarantine Pests	Number of Species *)	Total Percentage (%)	Frequency Intercepted Quarantine Pests in 2014 to 2018**)	Total Percentage (%)
Insects	274	33	15	7
Fungi	155	18.8	135	58
virus	143	17.2	5	2
Bacteria	68	11	19	8
Nematodes	76	9	56	24
Weeds	41	6	2	1
Mites	30	5	-	-
Snails and Slugs	31	4	-	-
Mollicutes	12	2	-	-
Total	830	100	232	-

*) According to MoA Decree No. 25 of 2020.

***) Data was obtained from Annual report of Agricultural Quarantine Agency (AQA), Indonesia in 2014 to 2018

as cited in Pusposendjojo, 2005; Suwanda, 2010), *Liriomyza huidobrensis* Blanchard on various host plants (Purnomo *et al.*, 2008), and Golden snail (*Pomacea canaliculata* L.) in lowland rice (Siregar *et al.*, 2017) are still an object of domestic quarantine. In 2014–2018, a total frequencies of 232 quarantine pests were intercepted. These were including viruses, bacteria, fungi, nematodes, insects, and weeds (Table 1). These species of quarantine pests were intercepted on the importation of ornamental plants, vegetables, food, and plantation crops from various countries in Asia, Europe, America, Australia, and Africa (Agricultural Quarantine Agency, 2015; 2016; 2017; 2018; 2019). The table showed that fungi (135 times) and nematodes (56 times) were the most predominant intercepted of quarantine pests.

Pest interception on importation pathway that the need to be careful on the potential entry and spread of various species of quarantine pests into Indonesian territory. The same case was reported by India during period of 2007–2010 that a total of 54 species of exotic pests were intercepted through the introduction of 116 plant species from 51 countries (Dev *et al.*, 2012 as cited in B. Singh *et al.*, 2018). Another report on chestnuts in Canada due to the introduction of the pests *Cryphonectria parasitica* (Murrill) Barr in 2000 (Fisher *et al.*, 2012).

In addition, efforts to prevent the spread of quarantine pests, a new paradigm of plant quarantine systems at present and in the future through strengthening supervision, innovation of pest control technology, and control of biological agents, invasive alien species, food safety, and food quality, protect wildlife and animals, and genetic resources (Table 2). The government has established a control norm for wild plants and animals (Ministry of Environment and Forestry, 2018), 187 invasive alien species (Ministry of Environment and Forestry, 2016), 915 agricultural genetic resources (Ministry of Agriculture, 2020), and 100 plant-based food safety species commodities (Ministry of Agriculture, 2016).

The existence of invasive plants such as *Opuntia engelmannii* Salm-Dyck ex Engelm, *Arenga obtusifolia* Mart, and *Merremia peltata* L. in Bukit Barisan Selatan National Park, Sumatra has caused environmental and economic impacts, especially in Ujung Kulon National Park on Java Island (Setyawati, 2013). Furthermore, Yuliana and Lekitoo (2018) reported 5 species of plants that need to be aware of their development, namely *Chromolaena odorata* (L.) RM King & H. Rob., *Lantana cammara* L., *Merremia peltata* (L.) Merrill, *Mikania micrantha* HBK, and *Spathodea campanulata*. P. Beauv. These invasive alien species have potential to destroy native species and biodiversity, causing ecosystem degradation and habitat loss.

Table 2. Quarantine concern's on Bio-Safety

No.	Control on <i>Bio-safety</i>	Number of species	Sources
1	Plant Quarantine Pests	830	Minister Decree No. 25 of 2020
2	Endangered Species	914	Minister of Environment and Forestry Decree No. P.92 of 2018
3	Genetic Resources of Agric.	915	Minister Decree No. 104 of 2020
4	Invasive Alien Species	187	Minister of Environment and Forestry Decree No. 94 of 2016
5	Bio-agent	Import Assessment Procedures	Minister Decree No. 411 of 1995
6	Genetic Modified Product	Analysis Method	Minister of Environment and Forestry Decree No. P. 69 of 2016
7	Food Safety	100	Minister Decree No.55 of 2016

RISK ANALYSIS AND TRACEABILITY AUDIT SYSTEMS

Law Number 21 of 2019 concerning Animal, Fish and Plant Quarantine has mandated as pest risk assessment (PRA) and an appropriate level of protection (ALOP) for the first entry of plants and plant products into Indonesia territory. Risk assessment, other aspects of supervision and control become the authority of the Plant Quarantine Inspectors that can be implemented thoroughly. This will be the main modality for strengthening plant quarantine system in Indonesia. The principle of scientific-based analysis is carried out by assessing the risk and determining the appropriate level of protection as stipulated in the SPS-WTO Agreement (World Trade Organization, 2002). Follow-up on the import of commodities, after risk assessment, and decision making are in accordance with the provisions of standards, guidelines, and SPS recommendations (Standards and Trade Development Facility, 2013). The SPS audit is carried out in the context of verification when conducting pest risk assessments, to see and ensure all conditions related to mitigating the risk of pest entry and spread into Indonesian territory. The traceability system can be strengthened by a commitment between stakeholders. For example, nutmeg that has been exported to the European Union has always received rejection and treatment after entering the export destination port because the aflatoxin content exceeds the acceptable limit (Agricultural Quarantine Agency, 2015). In addition, cocoa exports to the United States are subject to mandatory treatment after arriving at US ports. These two cases are very difficult to solve because the traceability system has not been properly implemented (Tasrif, 2017).

The important to note that, this system is to provide product certainty and guarantee if there is a notification of unsuitable agricultural products on the international market, traceability can be carried out, thereby taking steps to improve while maintaining product competitiveness, in the end, increase added value of Indonesian agricultural products (Suharto *et al.*, 2006; Tasrif, 2019).

PLANT QUARANTINE IN THE INDUSTRY ERA 4.0

Strengthening plant quarantine system in the industrial era 4.0 aims at efficiency and effectiveness of the use of resources, funding sources, quarantine facilities, and infrastructure. Therefore, pre-border activities can be carried out by promoting Mutual Recognition Arrangements (MRA) cooperation between the two parties so that risk mitigation of the entry and spread of pests can be mitigated. In addition, SPS provisions that can be implemented include quarantine pre-shipment inspection, pest-free areas and area of low pest or disease prevalence, recognition on equivalence, and quarantine pre-clearance (Dikin, 2018; Tasrif, 2018a).

At-border activities are emphasized by strengthening implementation and supervision strategies on quarantine pests and aspects of biological safety through customer-oriented plant quarantine service satisfaction such as risk categorization approach (low, medium, and high risk of plant and plant products). The quarantine service system can be improved based on quarantine compliance systems, criteria for categorizing customer compliance (compliance, and non-compliance). A reward and punishment system needs to be implemented through profiling of quarantine customers, so customers have a high level of compliance may get quarantine priority services (Tasrif, 2019). Post-border activities are more focused on the implementation of plant quarantine policies to see the effectiveness of the implementation of pre-border and at-border cases, through regular and continuous monitoring of pests, implementation of early warning systems and emergency responses in case of pest outbreak. New quarantine pests, strengthening standardization of plant quarantine premises also needs to be a concern in implementing quarantine (Tasrif, 2018b).

In the aspect of quarantine pest's detection, advances in pest detection technology in the industrial era 4.0 can provide benefits, especially in detection and monitoring of presence of pest populations in the field. Various latest technologies by utilizing drones and bio-sensors have contributed to the field of crop protection (Taufik *et al.*, 2019).

For example, the use of drone to survey for pests, such as Asian long horned beetles (*Anoplophora glabripennis* Motschulsky) in tall trees (Rosenthal, 2017). While, the use of biosensor platforms based on nanomaterials such as fluorescent silica nanoparticles (FSNPs) combined with antibody as a biomarker have successfully detected pathogens of cause bacterial spot diseases (*Xanthomonas axonopodis* pv. *vesicatoria* (Doidge) Dye) in Solanaceae plant (Yao *et al.*, 2009, as cited in Fang & Ramasamy, 2015). Furthermore, Carter and Cary (2007) recommend the use of Lateral Flow Microarrays (LFM) to enable hybridization-based nucleic acid detection and use a colorimetric signal that is easy to visualize. The use of other detection methods such as the use of Spectroscopy-based methods and Electrochemistry and photonics (Goulart *et al.*, 2010).

A1 Quarantine pests such as Karnal bunt (*Tilletia indica* Mitra) of wheat has been detected using bio-sensor technique and shown adequate to perform a rapid, easy, and reliable analysis. This technique of detection in order to identify the teliospores of contaminating fungus in wheat lots, which could be used by the seed certification laboratory and plant quarantine department (S. Singh *et al.*, 2012). Furthermore, the use of sensor for the detection of various plant pathogens include the use of red green blue (RGB) sensor for detection of *Cercospora* leaf spot disease (*Cercospora beticola* Sacc) in sugar plant (Neumann *et al.*, 2014), the use of Spectral sensors against brown spot disease (*Puccinia hordei* Oth), and powdery mildew (*Blumeria graminis* DC Speer) in barley (Kuska *et al.*, 2015; Wahabzada *et al.*, 2015). Thermal sensor for detection of orange rust disease (*Puccinia kuehnii* Krüger) in sugarcane (Apan *et al.*, 2004), use of fluorescence imaging for detection of Bean Common Bacterial Blight (*Xanthomonas fuscans* subsp. *fuscans* Schaad) in soybean (Bürling *et al.*, 2011).

Various types of sensors such as RGB, Multispectral, Hyperspectral, Thermal, Chlorophyll Fluorescence, and 3D sensors can be developed to quarantine pest detection tools in agricultural commodities. Development of various types of sensors in the system quarantine should focus on the detection of pests of food crops and main commodities of plantation crops (sugarcane, cocoa, rubber, and oil palm), food crops (rice, corn, and soybeans), horticulture

(shallots, chilies, and garlic). In addition, the use of big data and artificial intelligence can be integrated into the management of plant quarantine technology information systems to track the movement of agricultural products that have the potential to carry quarantine pests.

PROFICIENCY CERTIFICATION AGENCY FOR PLANT QUARANTINE

For efficiency and effectiveness in the implementation of a plant quarantine system in the future, apart from relying on existing human resources, in the future, human resource registration system can be adopted by implementing LS-Pro with various competencies to implementing quarantine measures and quarantine facilities, and infrastructure. Thus the government can strengthen supervisory regulations, prepare regulations, evaluate, and monitor the implementation of the quarantine policy (Tasrif, 2019). Currently, the implementation of plant quarantine treatment measures has been submitted to a third party, but registration is still through an internal management approach (Agricultural Quarantine Agency, 2014).

Law Number 21 of 2019 has mandated the implementation of quarantine measures (inspection, isolation, observation, treatment, and destruction), facilities, and infrastructure for quarantine measures, and assessors (Table 3). By granting some government authority to other parties (business actors) it is hoped that the government will focus more on planning policies, norms, and standards as well as evaluation of quarantine policies that ultimately aim the efficiency and effectiveness of the plant quarantine system activities in Indonesia.

POLICY RECOMMENDATION

Along with the issuance of quarantine regulations through Law Number 21 of 2019 concerning Animal, Fish and Plant Quarantine, the authority and scope of implementation of the plant quarantine system in an effort to prevent the entry and spread of quarantine pests into the territory of the Republic of Indonesia, as well as national biosafety surveillance (Bio-Safety) is expected to strengthen plant quarantine policies. These policy steps become a new paradigm in strengthening the current national plant quarantine

Table 3. Implementation on quarantine action and facilities through profession certification agency (LS-pro)

No	Activity	Basic Law	Priority
I	Competent of Human Resources 1. Inspection 2. Isolation 3. Observation 4. Treatment 5. Destroying	Article 62 Para 6 of Law No. 21/2019	Import, Domestic, and Export of plant and plant products
II	Installation Facility 1. Treatment 2. Destroying 3. Observation 4. Isolation 5. Inspection 6. Laboratory	Article 22 Part 4 of Law No. 21/2019	Import, export, and domestic of plant and plant products
III	Human Resources 1. Auditor 2. Assessor	Article 77, Law of 21/ 2019	Supply chain management

system and in the future, including (1) socializing the regulation of the plant quarantine system to all stakeholders; (2) efficient implementation of Quarantine Border Management (QBM) through risk categorization of carrier media and customer profiling (customer compliance); (3) increasing the efficiency of quarantine measures through the adoption of bio-sensor technology and drones, as well as other applications (chip technology and DNA based markers); (4) increasing human resource capacity (quality and quantity); (5) strengthening the traceability audit system; (6) integration of plant quarantine data and information management through the use of big data and artificial intelligence; and (7) delegation and empowerment of the business worker as partners through the professional registration system (LS Pro).

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