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# The Role of Traceability of Standardized Palm Oil Seed for Strengthening Smallholder Plantation in Indonesia

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## Abstract

*Oil palm has a very important economic value but also social-enviromental concern in several countries. Currently the top 5 world biggest producer are Indonesia 59%, followed by Malaysia 24%, Thailand 4%, Colombia 2% and Nigeria 2%. In Indonesia oil palm plantations continue to grow significantly which planted 3 difference companies (large private estate crop large state estate crop and small-holder estate crop). In terms of plantation management between large plantations and small plantations, there is a significant gap that affects the performance of small plantations. One of the most important factors to assurance the productivity of oil palm is availability of seed quality. Even though there are already standardization and regulations related to seed production, but the low quality or sub-standard seeds are still found on the market which are very detrimental, especially for smallholder. In this paper, traceability of palm oil seed in the system supply chain are reported based on the survey on around 80 percent of legally existing firms. The traceability are observed and various possibilities for the entry of sub-standard seeds into the market were analysed. Based on the facts, some recommendation are formulated to improve the effective conformity assessment to strengthen the small-holder plantation.*

**Keywords:** *oil-palm seed, small-holder, sub-standard, traceability, conformity-assessment.*

## Introduction

Oil palm has a very important historical and economic value in several countries in South-East Asia, South Asia, western states of Africa and Latin America. Currently the top 5 world products are Indonesia 59% of total world production with production capacity around 47 Mio ton, followed by Malaysia 24% (19 Mio ton), Thailand 4% (3.45 Mio ton), Colombia 2% (1.5 Mio ton) and Nigeria 2% (1.5 Mio ton) (USDA 2023. In Indonesia oil palm plantations continue to grow significantly. Currently, the position of the oil palm plantation area has reached more than 15 Mio ha which is 58.91 % planted by large estate crops (private and state own company) and has a production capacity of 30.06 Mio tonnes. Meanwhile, 41.09 % was planted by smallholder estate crops (plantation) with a production of 15.52 Mio tonnes (BPS 2023). Figure 1. Show the distribution of a large private estate crop, large state estate and small holder estate crop.

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In Indonesia the palm oil industry plays an important role for the Indonesian economy with the performance of the palm oil trade which continues to increase, and this industry also involves many business actors from various economic groups. The national oil palm plantations continue to grow significantly employ more than 17 million heads of households, farmers and employees who work in the on farm and off farm sectors The palm oil commodity has provided benefits from upstream to downstream by involving many business fields, employment, fulfil food needs and generating foreign exchange.

Increasing demand in the last 10 years and the diversification of oil-based products encourages the dynamics of demand and competition between vegetable oil commodities. To meet the increasing production needs, encourage the expansion of production areas through new plantings, replanting of old, non-productive plantations and replacing existing land areas. On the other side, increasing of productivity must pay attention about the global concern on enviromental impacts which often addressed to Indonesia such us loss biodiversity loss, climate change, soil ecosystems and microclimate. This also happen globally in other countries. A great public concern particularly related following issue: (1). production issues related to plantation management, labour shortages, replanting with improved crop varieties, mechanization etc. (2) Ongoing environmental and sustainability issues including deforestation, biodiversity loss and GHG emissions due to crop expansion. (3). growing threats arising from climate change, including biotic factors, such as pests and disease, that could impact crop performance in unpredictable ways; (4). Increasingly serious supply chain and consumer issues including potential trade barriers and boycotts. (Murphy et. al. 2021). In Indonesia, through certification scheme ISPO (Indonesia Sustainable Palm Oil) which done by independent institution, has implemented sustainable concept which balance between profit and social-enviromental concerns. Presidential Regulation Number 44 of 2020 and Minister of Agriculture Number 38 of 2020 become 'obligations' for oil palm companies and plantations. Especially in paying attention to various environmental and social aspects to ensure sustainability. At the same time answering the negative stigma against domestic palm oil (BPDPKS, 2021).

Efforts to increase production capacity more important that expanding planting areal. Productivity can be increased by improving plantation management, improving efficient supply chains and improving plant genetic quality. Increasing the production capacity and quality of palm products also includes overseeing smallholders in production, including the selection of superior palm seeds. In fact, in terms of plantation management and the technology applied between large plantations and small plantations, there is a significant gap that affects the performance and productivity of small plantations. One of the most important factors to assurance the productivity and quality of oil palm is availability of seed with high quality. There different kind of production seed system which different technology. Palm seeds must comply with the Nasional standard SNI 8211-2015 and decree of the Minister of Agriculture No.26/Kpts/KB.020/05/2021. The implementation of standards and regulations is a very important tool to guarantee the trading system of superior seeds and free of circulation of substandard seeds. However, in reality, low-quality or sub-standard seeds are often found on the market, which is very detrimental, especially for small farmers. (Chalil et al., 2018) reported in his study, in 2012 at North Sumatra Province has 80.28% of the smallholders people use seeds that are not certified. In 2015 similar conditions still arose 60% plasma plantations in Sumatra where as many 90% are smallholder plantations using seeds who are not certified. In 2018 amounted to 77.97% of people's plantations are still using it uncertified seeds

In research we report current situation of supply chain of oil seeds. The quality control and method of traceability of seeds were obtained by interview and field observation at different level of supply cain from the breeder or production seed, nursery and farmer. Various possibilities for the entry of sub-standard seeds into the market were also discussed. To validate of seed quality we analysed of the microstructure of seeds analysed using Fourier-transform Infrared Spectroscopy (FTIR) and Scanning Electron Microscope (SEM). This result by comparing existing traceability method is discussed to provide possibility of practical analytical traceability method. Furthermore, based on existing implementation of regulation, various fact finding in field, and recommendation from stake holder, some recommendation are discussed and formulated to improve the effective conformity assessment to strengthen the small-holder plantation.

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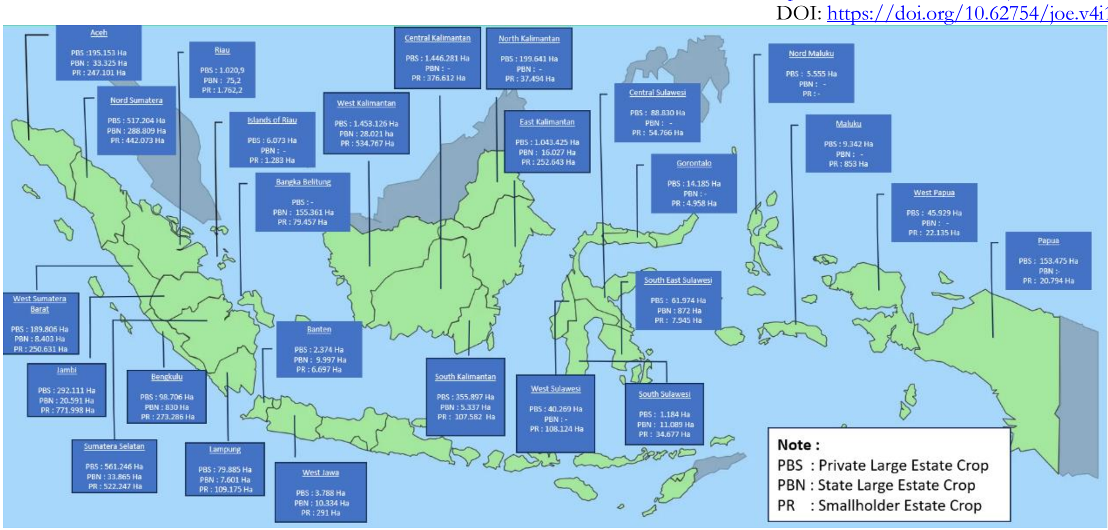


**Figure 1. Distribution and area of estate crop in Indonesia**

## Literature review/Study site

The Palm oil belong to a vegetable oil whose texture can be described as liquid, oily and fatty. Palm oil is extracted from the flesh of the palm fruit Most vegetable oils has very important function for food, biofuel and for feedstock the chemical industry. It is estimated that around 90 percent of palm oil is used for food consumption, while for industrial consumption such as cosmetic products or fuel and diesel fuel, the remaining 10 percent. Comparing with other oil producing crop, oil palms are significantly relatively more efficient than other oil-producing crops. A single hectare of land can produce 4.17 metric tons of palm oil a year, compared to just 0.56 tons of sunflower oil, 0.39 tons of soybean oil and 0.16 tons of groundnut oil (Anonymous, 2021).

*Palm Characteristics*

Oil palm belongs to the genus *Elaeis* of the *Arecaceae* family. This genus has two species - *E. guine*ensis (African oil palm) and *E. oleifera* (American oil palm). There are three fruit forms of *E. guineensis*, differing mainly in the thickness of their shells – dura (thick shell), Tenera (thin shell) and pisifera (without shell). Globally, palm oil is mainly produced from *E. guineensis* in the form of Tenera fruit. E. oleifera is not used commercially due to low yields. However, it is more disease resistant and can be grown in areas where *guineensis* cultivation is not possible, for example Central-South America [Barcelos et a., 2015). The Tenera type of palm seed is the result of cross-breeding between Dura and Pisifera to produce a thin layer of palm shells. The black color on the halves of the palm kernel is part of the palm shell. The layer of the palm shell is black. This layer is also known as the Endocarp. This layer has a thickness ranging from 20-50% of the volume of the palm fruit. The part inside the seed which contains the genetic seed and where the growth of the radicle and plumula begins is called the Endosperm layer which is about 4 – 20% thick of the palm fruit. The outermost part is the part which is the fruit of the palm fruit, namely the fruit layer or called the Mesocarp (Jain & Priyadarshan, 2009)

*Genetic improvement and breeding of oil palm*

Oil palm is an annual crop, so breeding programs take relative long time. Therefore, several genomic approaches have been used to shorten breeding times. Chan et al. (2017) reported an accurate and comprehensive annotation of the oil palm genome, focusing on the analysis of important gene categories (GC3-rich and intron-less), as well as those related to important functions, such as FA biosynthesis and disease resistance. This study demonstrates the advantages of having an integrated approach to gene prediction and developing a computational framework for combining multiple genome annotations. These results, available in the oil palm annotation database (http://palmxplore.mpob.gov.my), will provide an

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important resource for studies of the genome of the oil palm and related plants. The genome-wide SNP (single nucleotide polymorphism) approach can help study associations between 18 phenotypes of bunch components in oil palm germplasm of *E. oleifera* origin Suriname and Brazil Coari species, several interspecific hybrids and elite strains of *E. guineensis*. The genotyping by sequencing (GBS) method yielded a total of 459 million or around 798 thousand reads per sample and 3,252 SNPs met the requirements for 456 genotypes (PPKS 2017). Research achievements in the field of genomics began in 2013 by sequencing the transcriptome and genome. Early efforts were based on expressed sequence tags (ESTs) (Jouannic et al 2005), but the technique, although useful for tagging expressed genes, provided only partial coverage of the coding region and the genome. Subsequently, GeneThresherTM technology was applied to selectively sequence hypomethylated regions of the genome (Low et al. 2014). The oil palm AVROS Pisifera genome sequence was later released in 2013 (Singh et al. 2013], and this facilitated the completion of the oil palm dura genome draft. With genome sequence, coupled with genetic mapping and homozygosity via sequencing, the SHELL gene was identified (Jin et al. 2013). This facilitated efficient genetic tests to discriminate between the Dura, Pisifera and Tenera fruit forms. Furthermore, the VIRESCENS gene, which regulates the color of the fruit's exocarp], and the gene MANTLED, which causes tissue culture abnormalities, was also found. Accurate genome annotation is very important for the identification of these genes, and will be very important for increasing the productivity of oil palm (Singh et al, 2013; Singh, 2014; Ong-Abdullah, 2015, Sahputra, 2016)

Many breeding studies have been carried out by various companies and research institutes. The best dura × pisifera combinations have an oil to bunch ratio of 28–32% and can produce up to 10 tons per year. Crossing D x P PPKS 239 superior varieties from PPKS produced very good performance, from productivity to CPO (Crude Palm Oil) and PKO (Palm Kernel Oil) content. It was reported that in TM 4-6 years this variety could reach production of up to 30.5 tons/ha, and it increased again to 32.6 tons/ha during the 6-9 year crop period. The plants have started to bear fruit at the age of 2 years and have a yield potential of up to 10 tones/ha/year. The purpose of breeding is not only to get high CPO but also PKO. The price of PKO has a higher price compared to CPO. This variety can produce up to 8.4 tons/ha/year of CPO and up to 0.7 – 1 ton/ha/year of PKO. Other breeding results, for example the D x P PPKS 540 variety which is known to produce high CPO, which is then used as fuel in factories (Anonym, 2022)

*Impact of Seed Impurity*

Oil palm trees that come from seeds that are not pure bear fruit rather slowly, which can reach more than 48 months, while high-yielding oil palms generally bear fruit 36 months. Even in some areas, oil palm plantations that use sub-standard seeds find that the plants have not produced fruit after being planted for more than 6 years. In several cases, it was often found in smallholder plantations that production was far low due to the presence of 25% Dura trees and 25% Pisifera trees. The FFB productivity (Tons/Ha) of impure palm oil is below normal (< 20 Tons of FFB) and tends to continue to decline. Whereas for superior seeds, the peak production is above 20 tons of FFB and this production can be stable for more than 10 years. The bunch weight of superior oil palm 8-20 years is between 15-22.5 kg with the number of bunches of 10-15 bunches/tree/year. Furthermore, in relation to the processing process, it is known that the fresh fruit marking (FFB) from impure palm seeds is inefficient as a result of the high percentage of fruit in thick shells (Dura), while processing plants are designed for thin shells (Tenera). This inefficiency is caused by the various types of fruit with different mesocarp thicknesses (Anonym, 2022).

As it is known that the dura type of oil palm has a thick shell and has a CPO content of 70%. The Pisifera type, does not have a shell, usually has sterile female flowers and the bunches decay quickly before producing oil with 0% CPO content. Meanwhile, a cross between the Dura and Pisifera types produced the Tenera type of oil palm which is a hybrid derivative with a thin shell with a CPO content of up to 100%. The planting of impure seeds was mostly of the Dura type, for example in Riau involving a total of 231 farmers (Budiman, 2020). Use fake seeds in oil palm plantations in particular among the people's plantations is a fact which has not yet been resolved. Use False seeds cause huge losses, due to lower plant productivity, has a slower tendency fruitful, and susceptible to disease (Liwang Et.al. 2013, Pinem & Pratiwi, 2020.; Isharyadi, et.al. 2021).

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*Traceability by detection impurity seed*

The oil palm genome sequence is also help to develop of detection for tracking or traceability measurement. This for example used for the identification of the SHELL gene (Singh et al., 2013) which was shown to encode the MADS-box transcription factor that is homologous to the identity of the Arabidopsis ovule and a regulator of SEEDSTICK seed development. Two distinct amino acid substitution mutations in the dimerization and DNA-binding domains of the SHELL protein occurred in the spontaneous mutant shMPOB and shAVROS alleles. The mutant protein tends to act as a trans dominant negative isoform, which explains the codominant phenotype in Tenera palms. Molecular markers of the SHELL gene allele can be used to differentiate Dura, Tenera, and Pisifera plants in nurseries long before planting in the field. Screening at the nursery stage can eliminate dura palm planting errors and control the precision of hybrid seed production. Further yield increases were brought about by breeding Dura and Pisifera elders for a higher ratio of female inflorescences; bunch weight; ratio of oil to bunches; recovery of oil and previous flowering. The donors of these traits are the high-yielding Deli oil palm accessions; The AVROS line is characterized by precocity, high yield and growth power; Econa coconuts have a high oil to bunch ratio and Yangambi coconuts flower earlier (Sambanthamurthi et al., 2009).

Breeding results from several companies are also widely carried out, and for detection of impurity need a certain DNA Marker which not always available for public purpose because it involves company secrets, intellectual properties right. Some of them are open research only. Therefore, for certain methodology for tracking or measurement of traceability must be provide by government to support testing of impurity especially for free market seeds or for smallholder.

*Regulation to assurance the seed quality.*

On of the most important factors to assurance the productivity and quality of oil palm is the availability of seed with high quality (superior). This is more relevant for the small-holder because there lack to trace by themselves about the quality or purity of the seeds. To control the quality of seed, the government of rep Indonesia release the Nasional standard SNI 8211-2015 and regulation based of decree of the Minister of Agriculture No.26/Kpts/KB.020/05/2021. Seed production, breeder, nursery must follow the regulation. In the table 1 are described the requiremenst for technical procedure of breeding.

**Table 1. Requirements for technical procedure breeding according national standard SNI 8211-2015**

| No | Benchmark | Requirements |
|---|---|---|
| 1 | Population base Dura and population base Tenera or Pisifera | Own information family tree complete and documented lineage _ with Good |
| 2 | Method selection | Through progeny testing with method that has tested in a manner scientific |
| 3 | Testing Progeny | |
| | a. Test location | Specification pedo-agroclimatic certain |
| | b. Plan cross | Fulfil rule knowledge breeding and standard statistics |
| | c. Draft test | Fulfil rule knowledge breeding and standard statistics, at least have One cross standard and/ or every tested crosses can connected One with other |
| | d. Vegetative observation | At least twice during testing |
| | e. Observation production | Average from at least four observations year harvest consecutive |
| | f. Bunch analysis | Analysis equal oil with method *Soxhlet*, by the time the bunch is already develop perfect at least 4 takes sample at 6-month intervals |
| | g. Results data testing | Documented with Good |

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| | | |
|---|---|---|
| 4 | Criteria Selection Cross | |
| | a. Production of fresh fruit bunches (FFB) | ≥ 175 kg/ tree / year |
| | b. Palm products (crude palm oil [CPO] + palm kernel oil [PKO]) | ≥ 6 tons/Ha/ year |
| | c. yield factory (yield laboratory x 0.855) equivalent with method *Soxhlet* | ≥ 23 % |
| | d. Growth rise (measured after plant 6 years old after plant) | ≤ 80 cm/ year |
| 5 | Method Inspection | Appendix A |

Sources: BSN, 2023

**Table 2. Requirements quality sprouts**

| No | Benchmark | Requirements |
|---|---|---|
| 1 | Quality genetics | |
| | a. Origin material plant | Garden seeds that have set by the authorities competent on the name of the Minister of Agriculture |
| | b. variety | Seed superior plant plantation |
| | c. Purity | No not enough of 98% sprouts produce coconut palm type Tenera based on pollination blank |
| 2 | Quality pathological | OPT free |
| 3 | Quality physique | |
| | a. Weight seed | Minimum 0.8 grams |
| | b. Radicle and Plumula | |
| | - Long | The radicle is at least 0.3 cm and<br>The plumule is at least 0.3 cm |
| | - Colour | White yellowish |
| | - Direction grow | opposite direction |
| | - appearance | Can distinguished clearly |

Sources: BSN, 2023

## Methodology

The methodology of this research based on primer data obtained by field survey and interview from the seed producer/breeder and nurseries. Schematic frame work of research is described in the figure 2.

*Data collection through interviews with seed producers (breeders).*

To obtain primary data, in the first stage an interview was conducted based on a questionnaire that had been prepared based on a study of the literature and reviewed developments in palm oil plantations from websites, official news and consultations with several experts. The questionnaire that has been compiled is then validated by testing it on a seed producer and published after receiving feedback. After the repairs were made, standard questionnaires were prepared. Out of a total of 19 producers officially registered by the government, 14 were taken, the remaining 5 producers did not allow interviews to be carried out (1 was not in production, 2 companies were not ready for interviews and 2 others because the location was difficult to reach. The location of 14 respondents located 1 company in West Java, 2 companies in South Sumatra, 4 companies in North Sumatra and 5 companies in Riau

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Interviews were conducted in direct dialogue with the management and engineering groups at each company. Questionnaire questions were answered and developed for other problems. In addition, interviews were conducted at 3 nurseries which are located in Riau (2 nursers) and in West Java (1 nursery). The purpose of these interviews was to confirm the results of the interviews at the producer level.

*Field observation:*

Based on the results of the interviews, a visit was made to the field to see directly the pollination process and the seed production process. Discussions are held for each stage of the production process, and it is possible to cross check with management. During the observation, open-ended questions were also asked based on the problems that arise and recommendations for improvements to the oil palm seed supply chain system. Apart from that, questions about the challenges and opportunities of developing a better production system were also discussed. Through the use of this methodology, interviewees have space to share their thoughts and experiences and raise unexpected issues beyond predetermined questions (Hollway and Jefferson, 2000).

*Data analysis.*

Based on interview data and field observations supplemented with data from news from the official website, and news from various webinar forums and FGDs with related themes, consultations with experts, national statistics agencies, research reports on related themes, regulatory policies, and standardization.

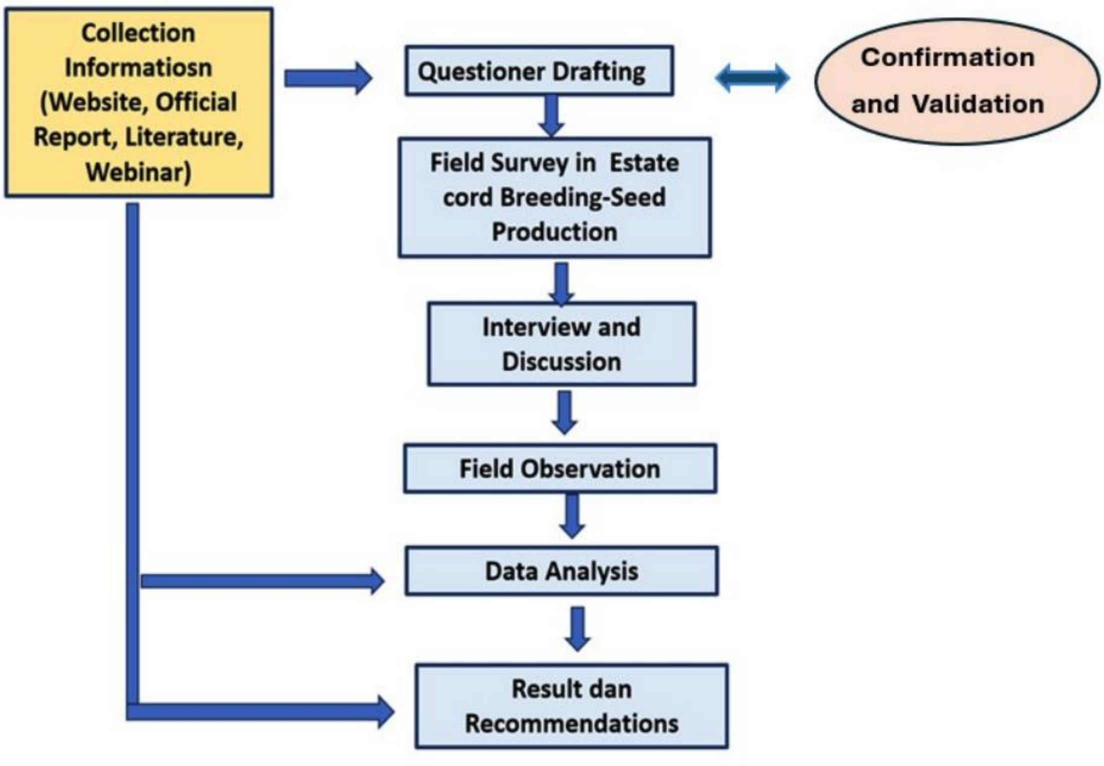


**Figure 2. Schematic frame work of research**

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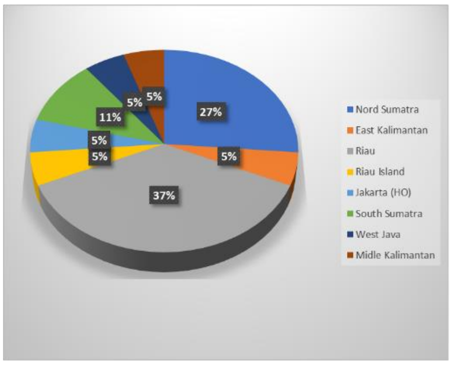
## Results and Discussion

*Productions, supply chain and traceability of palm oil seeds*

*Distribution of small holders, nursery and breeders*

For the supply chain of oil palm seeds, it is necessary to know about the distribution of plantations. In Indonesia, the types of plantations are divided into large private plantations, large state plantations and small plantations. The distribution of these types of fractures is almost in large islands which generally have a wet tropical climate such as Kalimantan, Sumatra, West Java, Sulawesi and Papua. For Nusa Tenggara, East Java and Central Java, there is no significant number of oil palm plantations. As previously described, large plantations are located in Kalimantan, Sumatra and Sulawesi. For small plantations, it is generally distributed in West Kalimantan, East Kalimantan, Central Kalimantan, North Sumatra, Riau, South Sumatra and the Riau Islands. In relation to the supply of oil palm seeds, As shown in Figure 3, seed producers are in Riau, occupying 37%, North Sumatra 27%, South Sumatra 11%, and others in West Java, Central Kalimantan. Riau islands

Figure 4 shows the number and distribution of breeders-seed producers across the countries from Aceh to Papua. It shown that nurseries of breeders or seed producers which are generally located in Riau, North Sumatra and South Sumatra. From 19 breeder companies surveyed, 14 companies were surveyed. Apart from selling these seeds for their own needs, they are also sold for the export market and for the domestic market, where the buyers are small holders, either directly or through intermediaries. As intermediate supply chain is the nursery. The distribution of oil palm seed cultivators is in Sumatra 8 provinces, on the island of Kalimantan there are 4 provinces and for the island of Sulawesi there are three provinces. The total number of cultivators for oil palm seedlings was 177, on the island of Sumatra 94 breeders, on the island of Kalimantan 64 and on the island of Sulawesi 19 breeders. When compared between the distribution of oil palm seed producers and the distribution of breeders, it is not balanced. This can reduce transportation logistics from seed producers to seed growers.



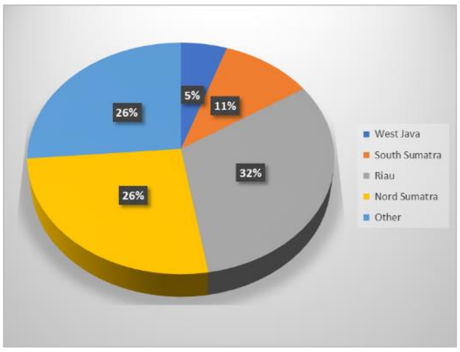




**Figure 3 Distribution of breeders-seed producers total (left ) and observes object (right)**

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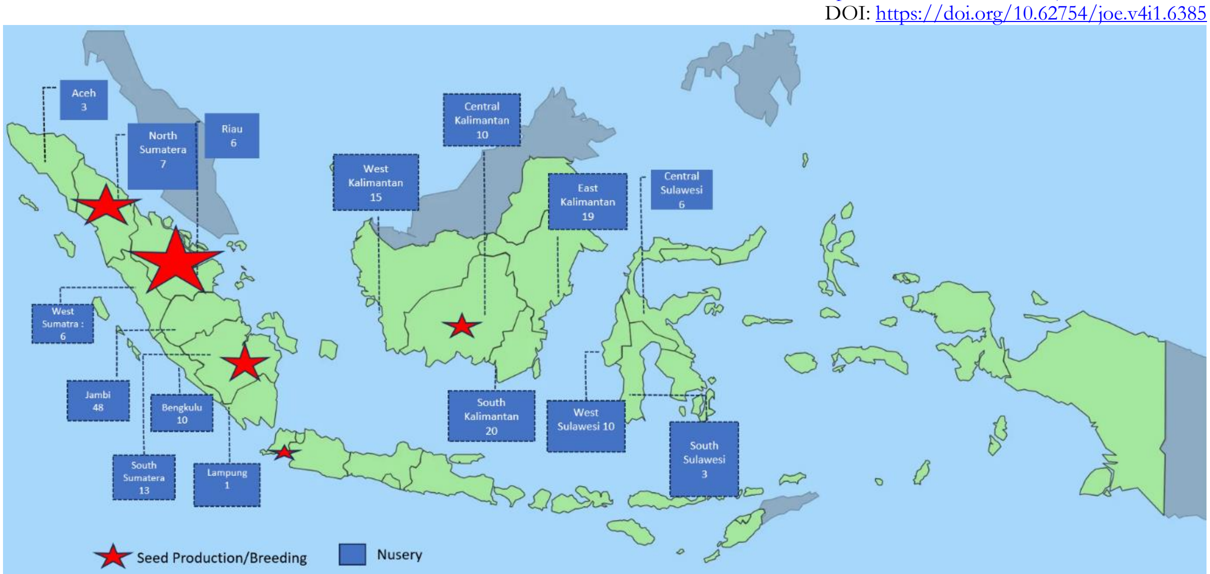


**Figure 4. Distribution of breeders-seed producers and nurseries**

*Quality control during seeds production and traceability of Seed Production*

Based on interviews with the technical team of respondent at the breeding company, and in conjunction with field observations which is carried out at the 14 seed-producer/breeder. The production process are conducted generally in following process stages: breeding of oil seeds, seed reproduction, seed processing, germination, and finishing (Figure 5). The variation of technology, equipment used in process production, material support, and the skills of technician varied depending on each own standard operating procedure but the goals is the same to comply with national standard.

Fist stage of production started by breeding which is carried for many years ago before. The breeding is done by setting up establish of basic population, selection method, progeny testing and cross selection. In seed reproduction, the mating design of the development of the main garden is carried out after selecting the suitable elders The containment process is carried out using 2 lids which spayed with pesticide. The determined bunches are also covered using poly-net to avoid loss caused by the falling of the seeds from the bunch. When the bunches that are ready to be harvested are then cut and brought to the production unit. At this stage, blank pollination is carried out for control pollination quality and to measure whether the applied method not lead free contamination.

At the seed processing stage, labelled bunch mother garden it is moved to storage and fermented for 2-5 days. Thereafter bunch crushed by thresher machine. Threshing of the seeds was subjected for stripping the mesocarp to remove the outer skin to obtain a clean seeds material. the removed mesocarp waste is collected and flowed to the oil production unit.. Clean Seeds are then sent to the germination process. In the germination proses, the seeds are soaked in clean water which added a antiseptic chemical and continue heating and drying at a certain humidity. The seeds that have been produced are then sorted manually based on seed weight and to remove defective seeds. Seeds that have been sorted then enter the seed dormancy process. The dormancy process is carried out by soaking and also temperature treatment. After that, the seeds enter the germination process, where the sprouts produced are monitored periodically until they meet standard requirements. The sprouts produced are then packaged using different colored plastic based on the variety and sealed using a special seal and given a barcode identification. Each process is always carried out by examining the quality of the sprouts. The selected sprouts are then processed and labeled and packaged with identification information from the seeds

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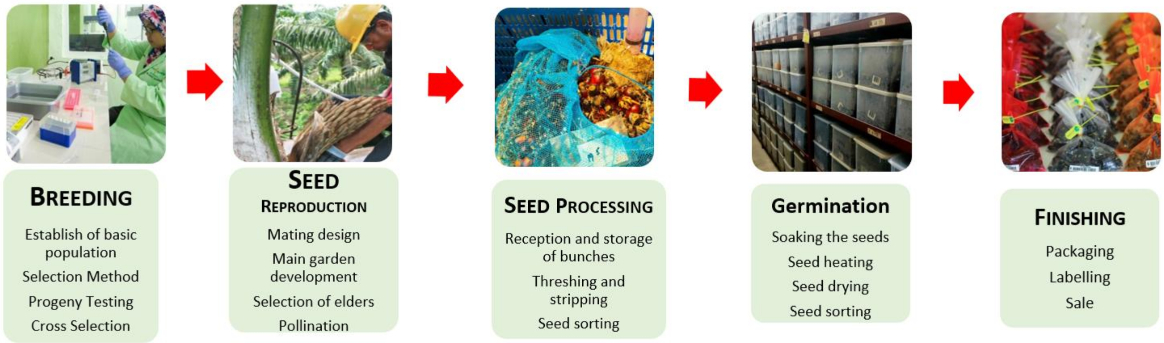


**Figure 5. Process production of oil palm seeds**

The critical stage in the process chain is the pollination stage, because this stage will affect the quality of the seeds. To obtain description how the breeder follow the standard, The responds of all respondents related to the activities for controlling the pollination process are described (Table 2). Checking at this stage is carried out with the parameters of whether the following work is done or not: (1). Examination of the condition of the main Dura garden; (2).Examination of the condition of the Pisifera mother garden; (3).Provided from the main garden that has been determined by the Government; (4).Prospective seeds are reproductions of varieties released by the Government; (5). Prospective Seedlings are more than 5 years old with healthy conditions (no disease); (6).Bunch analysis has been carried out with a total of 4 samples (in 2 years of observation) and if the lines are pure (inbred), 2 bunches are sufficient.; (7).The parent number is the one listed on the list of mother/father trees that have been approved by the Directorate General of Plantations; (8). Bagging conditions must be correct and good so that it does not allow outside elements (such as water and insects) to enter which can cause seed contamination; (9).Estimated bunch age compared to pollination time; (10)The health of the bunches is indicated by the absence of pest/disease attacks on the plants; (11).The existence of a label that is firmly attached to the bunches; (12).The results of blank pollination indicate that the chance of contamination during the pollination process is no more than 2%

Regarding the production capacity of each respondent, as shown in the graph (Figure 6), it varies from company to other company. Seed production capacity ranges from 20 thousand to 3.2 million. In general, they have between 100 thousand and 500 thousand, there are 9 companies, while those above 3000 thousand per month. (2 companies). Furthermore, it is known that not all producers use the full installed capacity, and demand is heavily affected. because the balancing process is limited in time.

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**Table 2. Quality control during pollination proses**

| No | Parameters | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Examination of the condition of the main Dura garden | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| 2 | Examination of the condition of the Pisifera mother garden | Y | Y | Y | Y | N | N | Y | N | N | Y | Y | Y | Y | Y |
| 3 | Provided from the main garden that has been determined by the Government | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| 4 | Prospective Seeds Are reproductions of varieties released by the Government | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| 5 | Prospective Seedlings are more than 5 years old with healthy conditions (no disease) | Y | Y | Y | Y | Y | y | y | y | y | y | y | y | y | Y |
| 6 | Bunch analysis has been carried out with a total of 4 samples (in 2 years of observation) and if the lines are pure (inbred), 2 bunches are sufficient. | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| 7 | The parent number is the one listed on the list of mother/father trees that has been approved by the Directorate General of Plantations | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| 8 | Bagging conditions must be correct and good so that it does not allow outside elements (such as water and insects) to enter which can cause seed contamination | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| 9 | Estimated bunch age compared to pollination time | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| 10 | The health of the bunches is indicated by the absence of pest/disease attacks on the plants | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| 11 | The existence of a label that is firmly attached to the bunches | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| 12 | The results of blank pollination indicate that the chance of contamination during the pollination process is no more than 2%. | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |

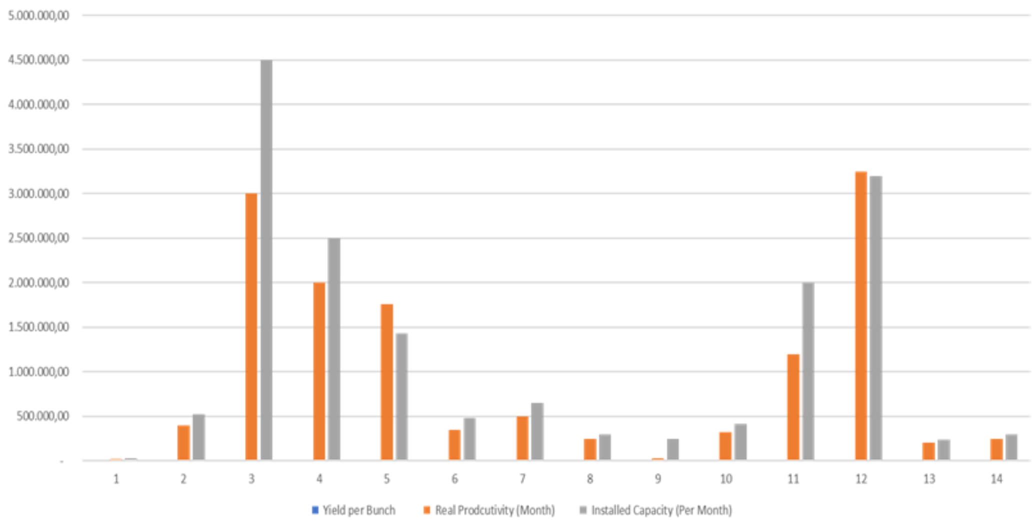


**Figure 6. Productivity of seeds, compare of existing capacity**

*Traceability of seed purity during distribution and destination market*

To increase the traceability of seed purity during distribution there some tracking methode. To maintain seed purity, each respondent has a certain method to track production. Table 3 shows how to label and how to observe product purity. The methods developed vary greatly depending on the technology and

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investment allocated. The following is the method developed: (1). Using production code printed on the label; (2). use of ink injection system (laser); 3. Monitoring labels, and print logo on sprouts; (4). Each bag sent is sealed with a unique code number which is only sent to one company; (5). All seed data sent is documented in the SPU and Sales & Marketing sections; (6) Labeling (with barcode), bunch reference number, package seal number; (7). Certificate, QR Code on the bean bag, QR Code on the crate, (8). Trace Back with Code BREF; 9. Using a database of consumers who have purchased sprouts according to production batches; (10). Documents of the company's internal germination lines and the Provincial Plantation Service, labels on the seeds; (11). Direct to Production-Distributor; (12). Laser printing Labeling on the Seeds; (13). Monitoring of plant growth is carried out from the nursery to the production plants

**Table 3. Tracking in the distribution system dan Destination market**

| No | Tracking system for seeds that have been distributed | Destination of Marketing |
|---|---|---|
| 1 | The production code printed on the label | Sumatra, Kalimantan, Sulawesi, Java |
| 2 | Limited to the use of ink injection system (laser0 | All Provinces in Indonesia and Export |
| 3 | Monitoring label, and print logo on sprouts | Sumatra, Kalimantan, Sulawesi |
| 4 | Each bag sent is sealed with a unique code number which is only sent to one company. | All Provinces in Indonesia and Export |
| 5 | All seed data sent is documented in the SPU and Sales & Marketing sections | All Provinces of Indonesia |
| 6 | Label (with barcode), bunch reference number, package seal number | All Provinces in Indonesia and Export |
| 7 | Certificate, QR Code on the bean bag, QR Code on the crate | Kalimantan, Sulawesi, Papua |
| 8 | Trace Back with Code BREF | Sumatra, Bangka Belitung, Kalimantan |
| 9 | Using a database of consumers who have purchased sprouts according to production batches | Internal use only |
| 10 | Documents of the company's internal germination lines and the Provincial Plantation Service, labels on the seeds. | All province in Indonesia |
| 11 | Direct to Production-Distributor | Kalimantan, Bangka Belitung, Sulawesi, Papua |
| 12 | Laser printing Labelling on the Seeds | All Province of Indonesia<br>Export Africa, Amerika Latin, Asia |
| 13 | Monitoring of plant growth is carried out from the nursery to the production plants | All Provinces of Indonesia<br>Export Amerika Latin Afrika dan India |
| 14 | No available Information | Aceh, Sumatra, Bangka Belitung<br>Kalimantan, Sulawesi |

As for the market for palm products to meet the domestic and export markets. For the domestic market, it is generally used for own use in the same companies and for trading. The destination of marketing (Table 3 ), show that there are 7 companies from 14 supplied the seeds to the entire province of Indonesia. 5 companies besides filled the domestic market also export to several countries in Africa, Latin America and Asia. 6 companies supply to limited provinces and 1 company does not trade because the seed used for own plantation.

The way to marketing of seeds are carried out in the following way: 1.Direct purchases by farmers; 2 Direct purchase by breeders, 3. Distribution to the locations of farmers / breeders, Distribution to farmer/breeder locations by third parties, Through online ordering, Through market place (Tokopedia, Shopee, others). The Table 4 show the distribution way conducted by each seed breeder.

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Table 4. The way of marketing of the seeds

| No | Parameters | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Direct purchase by farmers | Y | Y | Y | Y | Y | Y | Y | Y | N | Y | Y | Y | Y | Y |
| 2 | Direct purchase by breeders | Y | Y | Y | Y | Y | N | Y | Y | N | Y | Y | Y | Y | Y |
| 3 | Distribution to the location of farmers / breeders | Y | N | Y | N | N | N | N | N | Y | N | N | Y | Y | N |
| 4 | Distribution to farmer/breeder locations by third parties | N | N | Y | N | N | N | N | N | N | N | Y | N | Y | N |
| 5 | Through online ordering | N | N | Y | N | Y | N | Y | N | N | N | N | Y | N | N |
| 6 | Through market place (Tokopedia, Shopee, others) | N | N | N | N | N | N | N | N | N | N | N | Y | N | N |

*Summarized supply chain of oil palm seed and possible entering impurity oil palm seeds*

Based on quality assurance observations and traceability tracking systems, each production process is carried out very well and has little chance of counterfeiting. However, based on interviews at the nursery level, there are fake seeds (impurity) found in several location. There are several possibilities that impurity seed enter the supply chain system like shown in the Figure 7. Even though at the first stage at breeder the purity of seed mostly managed by control of the traceability, but and the next level at nursery which don't have tools to track back, so the possibility uncontrol will be happen. This affected to next stage of distribution next stage of the supply chain, starting from breeders, traders and farmers, seeds are encountered that are not certified or whose origin is unclear. a figure described several possibility of seed supply chains. The first the supply chain is from the registered producers to their own plantation themselves. Secondly, there are also from the registered producers to small farmers which are categorized as plasma and guided by core company. Third, there are registered seed producer-breeders who distribute through nurseries by agreement, then continuing distributed to small holder plantation. In several cases breeders were found that were not legal (not registered) and could contribute to distribute sub-standard seeds which contain impurity (fake) seeds. These could enter the following supply chain and distribute of low quality substandard seeds Another possibility is that there are not registered breeders who illegally produce seeds and sell them to farmers. Moreover, there are cases when smallholder sell the planted land to another smallholder. If the seeds used for the planted land with are substandard seeds, the next farmer will maintenance the plantation with low quality of seeds which will lose their expectations.

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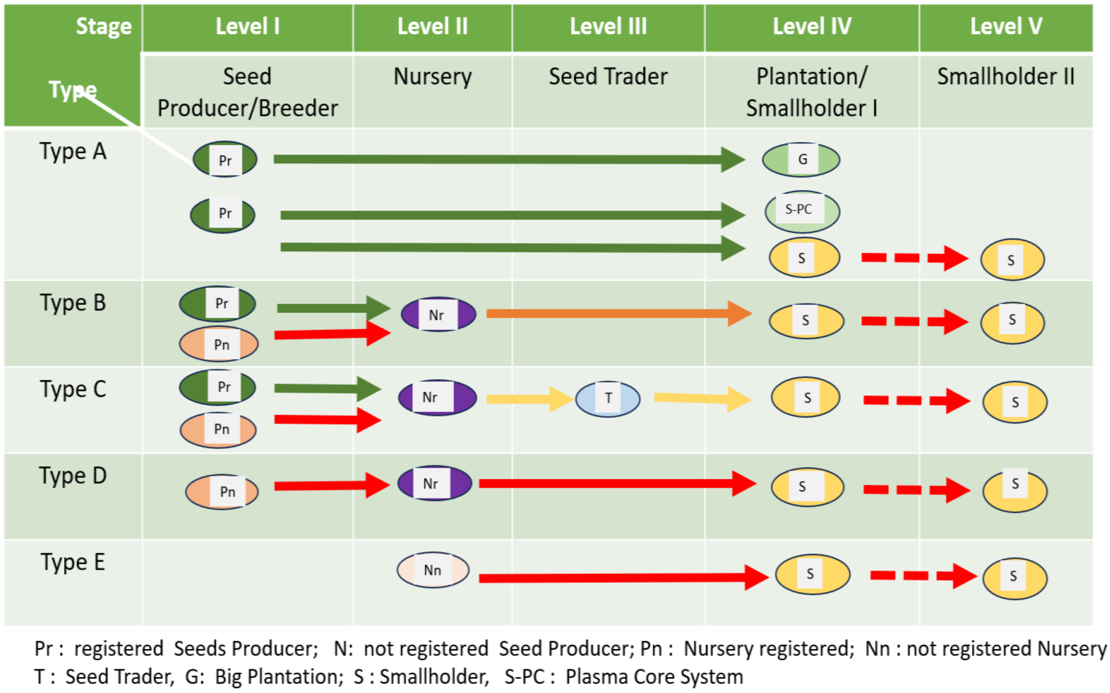


**Figure. 7. Summarized supply chain of oil palm seed and possible entering impurity oil palm seeds**

*Challenge to improve the conformity assessment to assurance the traceability of seeds*

Based on interview from the respondent, and expert, there are some possibility to reduce the distribution of substandard seed for example by law enforcement by local government and increasing awareness of smallholder. To strengthening to law enforcement can be carryout by capacity building for the inspection. However, to ensure law enforcement runs properly, a more reliable system is needed. Based on successful examples of other fields in guaranteeing and supervising for other types of products, third parties can work according to standards. Because the conformity assessment system with standards has been running well for years, it can be applied in the oil palm seed supply chain system. Assessment of the suitability of oil palm seeds with standards can be carried out by a certification body that works based on ISO 17065 which is carried out by a third party. This certification body operates and is evaluated by a national accreditation body which is a member of an international accreditation body. The governments can issue regulations to the nurseries to implement this kind standard voluntary or mandatory. In Indonesia system, the certification company must be accredited by National Accreditation Committee (KAN) which already member to International Accreditation Forum (IAF). Accreditation activities are very important in supporting the application of standards so that the conformity of products, services, processes, and management can run in accordance with the requirements and standards applied. The National Accreditation Committee (KAN) carries out the function of providing formal acknowledgment and approval of the integrity and competence of the Certification Company as part of Conformity Assessment Body (CAB) to carry out conformity assessment activities.

## Conclusion

Oil palm for Indonesia belong to strategic commodities because it is a source of state revenue and employing many people in the supply chain of product from upstream to downstream. In near the future oil palm plantations continue to grow significantly by improvement of on fam governance and also expanding the land area. There are 3 difference companies (large private estate crop large state estate crop and small-holder estate crop). One of the most important factors to assurance the productivity of oil palm is availability of seed quality. Even though there are already standardization and regulations related to seed production, but the low quality or sub-standard seeds are still found on the market which are very detrimental, especially for smallholder. Traceability system is needed for the development of a good quality seed for smallholder. Based on survey and interview from around 80 percent of seed producer-breeder shown that the traceability of seeds are carried with proven system. The distribution of substandard seed are identified in the nurseries which found a substandard seed. Various possibilities for the entry of sub-standard seeds into the market were must avoid by establishment a better system also discussed. To support the reduction of distribution of substandard seed, availability of simple accessible method for detection of impurity of seed is very crucial. One of important recommendation is conformity assessment based on ISO 17065 by third parties which accredited by National Accreditation Body. Such a recommendation are already proven in other system dealing with certain product and service based ISO standard to strengthen the small-holder position

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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