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Expanding Hybrid Rice Production in Indonesia

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Jakarta, Indonesia
July, 2019

EXECUTIVE SUMMARY

With a large population size that rapidly continues to grow, Indonesia needs to satisfy a growing demand for rice if it wants to prevent further rice price increases. Indonesian rice prices are already twice as high as on international markets and imports, while unpopular, are still necessary to cover shortages.

Hybrid rice has the powerful potential to increase productivity. It has an average annual productivity of 7 tonnes/ha, compared to 5.15 tonnes/ha produced by inbred rice. However, hybrid rice only amounts to less than one percent of the rice planting area in Indonesia, and has stagnated for several years.

Farmers generally find planting hybrid rice valuable. Farmers in Lombok experienced yields of 10.4 tonnes/ha compared to max. 8 tonnes/ha by inbred rice varieties. The additional yield brings about Rp 10 million additional annual net revenues per hectare.

A lack of proper extension services, some problems of hybrid rice varieties, and unmet customer preferences have prevented the sustained adoption of hybrid rice by Indonesian farmers. Moreover, import restrictions limit farmers' access to a continuous supply of seeds, which makes it less attractive for them to invest time and effort into the transition to hybrid rice.

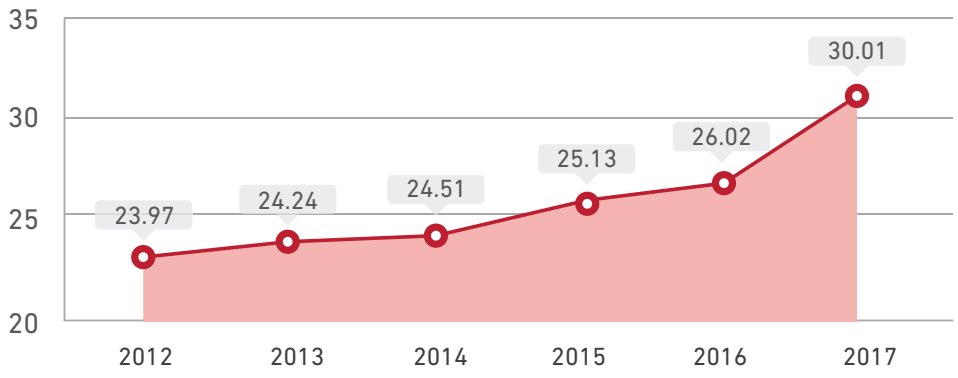
If hybrid rice is to reach levels like in China (51 percent of total rice acreage) and Pakistan (25-30 percent), it is important for the private sector to cooperate with the Indonesian government in developing and commercializing appropriate seed varieties. For the time being, imports remain important; not only to create sufficient supplies of seeds, but also to test whether certain hybrid rice varieties are suitable to local conditions in Indonesia. Once there are sufficient capacities to develop these varieties in Indonesia, the reliance on imports will naturally diminish.

This depends to a significant extent on the available technical expertise in Indonesia. Hybrid rice development in Indonesia is currently constrained by the low number of experts who are able to develop new varieties. To sustainably replace seed imports, human development programs need to be done in cooperation with local universities. The establishment of research centers in different parts of the country allows for the development of varieties that suit particular consumer preferences as well as climate and soil conditions in different parts of the country.

INDONESIA'S RICE SUPPLY PROBLEM

Indonesia is among the world's largest consumers of rice, with an estimated consumption rate of 97.6 kg per capita per year in 2017. With the large size of the population (264 million in 2018) and an annual population growth rate of 1.27 percent (2018), Indonesia has to provide an enormous amount of rice to ensure food security in the future (Ministry of Agriculture, 2018; Ashari and Rusastra, 2014). The total amount of rice consumed by Indonesians has continuously risen (Figure 1) and projections estimate that the per capita rice consumption will gradually increase by 1.5 percent to 99.08 kg per capita per year in 2025 and by 2 percent to 99.55 kg per capita in 2045 (Bustanul Arifin et al. 2018). As this applies to a population that, according to Statistics Indonesia's (BPS) "Indonesia Population Projections 2015-2045", is expected to grow to between 311 million and 318.9 million people in 2045, there will be an enormous additional demand for rice in Indonesia. Experts estimate that Indonesian rice productivity has to be increased to at least 6 tonnes/ha in order to cover domestic demand in the future (Ashari and Rusastra, 2014).

Figure 1.
Rice Consumption in Indonesia 2012-2017
(in million tonnes)

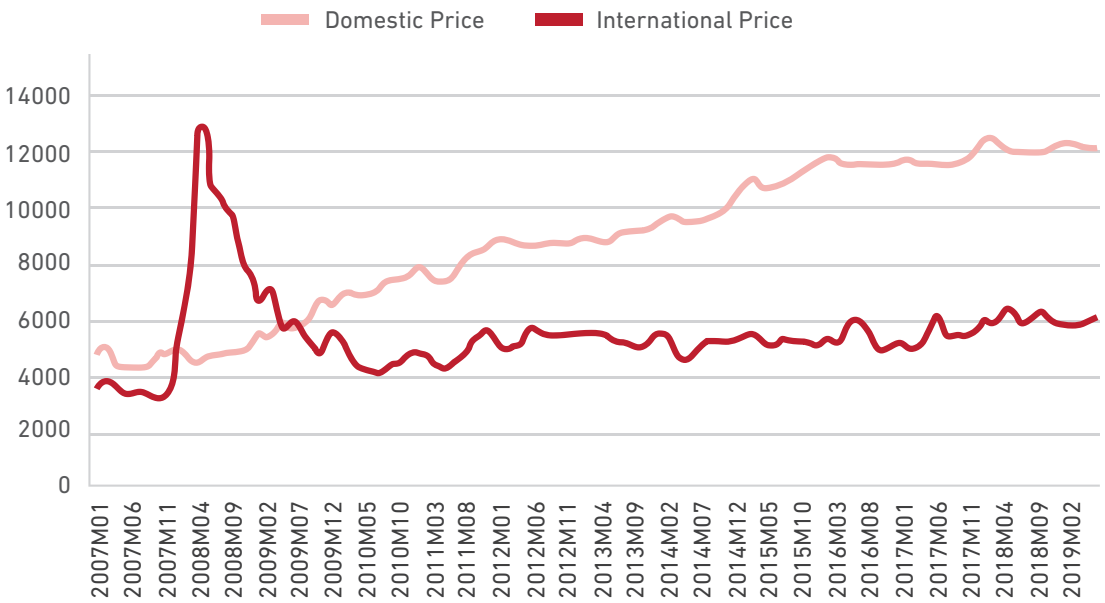


Source: Statistics Indonesia (2018)

Until recently, Indonesia has attempted to pursue a policy of rice self-sufficiency. The Ministry of Agriculture has maintained that Indonesia's rice productivity is adequate to satisfy the consumption levels, with a surplus of 15-20 million tonnes per year between 2013 and 2017. However, Indonesia continued to import rice during these years and recently imported 256,000 tonnes in 2017 and 2 million tonnes in 2018 (Statistics Indonesia, 2018).

Despite these imports, Indonesian consumers have to pay twice the price of rice compared to international markets. Between 2014 and 2019, international rice prices rose by about 12 percent, while rice prices in Indonesia rose by over 26 percent. The following chart shows the comparison of rice prices in Indonesia and in the international market (Figure 2). The chart shows that there is a rising trend of rice prices in Indonesia, despite the relatively stable price in the international market.

Figure 2.
Rice Prices in Indonesia Compared to International Rice Prices (2007-2019)



Source: Statistics Indonesia and World Bank Pink Sheet (Converted by x-rates.com) (2007-2019)

High rice prices reduce rice availability and ultimately contribute to malnutrition and stunted growth that affects more than 50 percent of the children in East Nusa Tenggara Province (Beal et al., 2018) and about a third of all five-year-old children in Indonesia. A study by the Center for Indonesian Policy Studies (CIPS) estimated that a rice price increase of IDR 1,000 reduces monthly household consumption in Sumba by 0.673 kg and eventually leads to an increased probability of a household having a stunted child by 2.44 percent (Ilman and Wibisono, 2019).

> However, easing import restrictions and allowing the private sector to conduct imports of rice are difficult decisions to take, due to their political significance. Other methods of increasing rice availability, namely increasing production and productivity of rice, are considered more politically acceptable, and are indeed the policies being pursued by the government.

According to a 2017 CIPS study, a factor that prevents rice prices from falling is the monopoly on importing medium-quality rice held by state-owned logistics company Bulog (Patunru and Respatiadi, 2017). However, easing import restrictions and allowing the private sector to conduct imports of rice are difficult decisions to take, due to their political significance. Other methods of increasing rice availability, namely increasing production and productivity of rice, are considered more politically acceptable, and are indeed the policies being pursued by the government.

During his first term in office (2014-19) President Joko Widodo's development priorities ("Nawacita") included the creation of an additional 1 million ha of rice fields outside Java (KPU, 2014). This was intended to compensate the loss of lands suitable for rice fields due to industrialization, deagrarianization and changing demographics (Sudaryanto, 2018). However, such policies have not been entirely successful. The Merauke Integrated Food and Energy Estate (MIFEE), for instance, was accused of displacing 50,000 indigenous persons and appropriating their lands (GRAIN, 2015). The clearing of such large swathes of land for agricultural purposes also raised environmental concerns (Greenomics Indonesia, 2012), releasing large

amounts of carbon and destroying the habitats of endemic species (GRAIN, 2015).

This makes increasing the productivity of Indonesian rice plants an attractive alternative. Indonesian rice productivity has been improving but it still lags behind that of Vietnam (5.55 tonnes/ha) and China (6.91 tonnes/ha); currently, rice productivity in Indonesia stands at a national average of about 5.15 tonnes/ha (Figure 3). Increasing productivity of rice is a socially and environmentally responsible choice, especially as doing so will also improve the wellbeing of the farmers, for whom greater yields translate into greater income.

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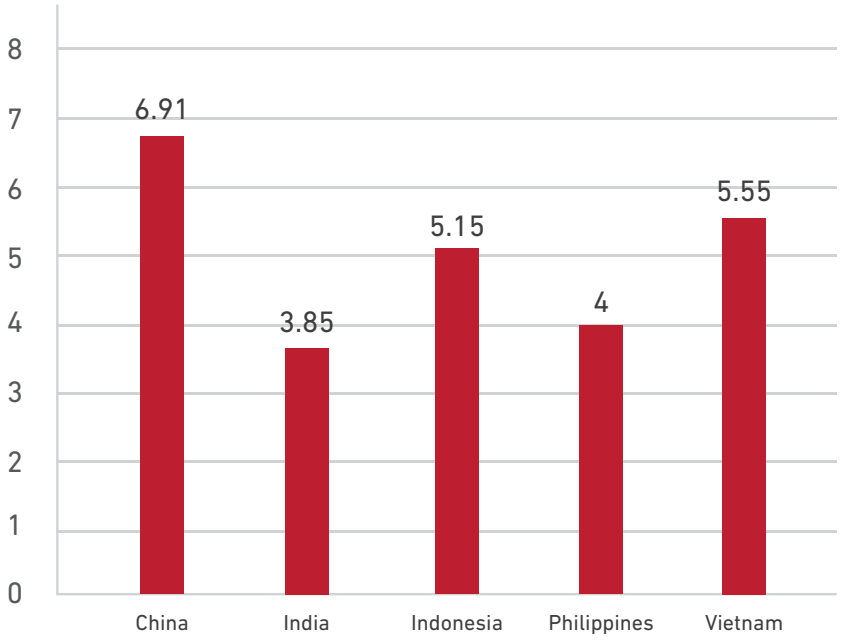
Figure 3.
Rice Productivity in Indonesia and Selected Countries in tonnes/ha in (2017)



Source: FAO (2019)

WHAT IS HYBRID RICE?

> Hybrid rice is bred from two different plants with different characteristics. Breeding efforts carry the expectation that the resulting offspring will inherit the better qualities of both parents. This means that the offspring produces higher yields.

While rice is a self-pollinating plant (each individual plant having both male and female reproductive organs), hybrid rice is bred from two different plants with different characteristics. Breeding efforts carry the expectation that the resulting offspring will inherit the better qualities of both parents. This means that the offspring produces higher yields.

In the process of breeding hybrid rice, three types of plants are required. The A line is sterile on the male side, which means it is a plant with inactive male reproductive organs. It needs to be pollinated by another plant, called the restorer line (R line). The R line is a normal plant of a different variety from the A line. The result of breeding the A and R lines is the hybrid offspring, called F1. Another plant, called the maintainer line (B line) is bred with the A line to produce more A line plants; A and B line plants are of the same variety, with the difference that A is male-sterile (cannot self pollinate), while B is normal. B and R line plants, which are self-pollinating, are bred in different plots to prevent contamination.

The development of hybrid rice requires a method of obtaining male-sterile rice plants for the A line, which requires technological intervention beyond the capability of regular farmers. In Indonesia, the main developer of hybrid rice is BB Padi, a government research and development agency.

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Producing hybrid rice seeds is still relatively complex; the farmers producing the seeds need special trainings provided by companies that are contracting them to produce the seeds. They need to ensure that A and R plants mature at the same time, sometimes even planting different batches of A plants on different dates to ensure maturity at the same time.

Both A and R lines are planted in one plot, isolated from other rice plants nearby. The A line plants are interspersed with R plants, usually 4-5 lines of A for 1-2 rows of R. The A plants are pollinated artificially by pulling a stretched rope through the rows of R plants to shake the pollen, which fall and fertilize the A plants. The resulting F1 seeds are then processed and dried, packed, labeled and sold by the company. A similar process is done using A and B plants to produce more A plants; in this case B plants are used instead of R plants.

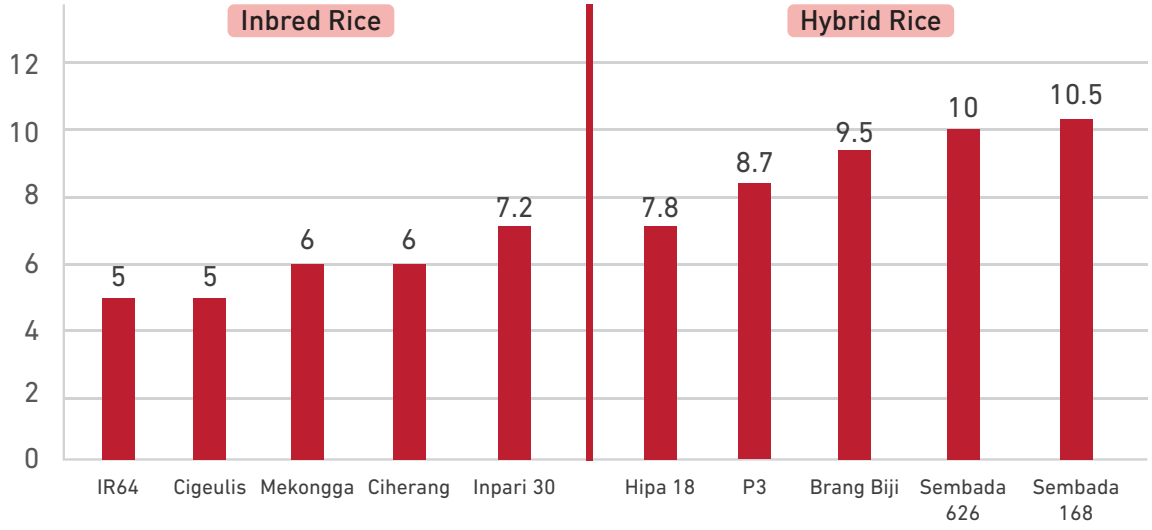
F1 seeds are usually produced during a short period of time beginning in the late dry season. The seeds have to be ready before the rice-planting season begins, and the breeding grounds have to be adequately but cautiously watered. This means that not all locations are appropriate for breeding hybrid rice seeds: in Indonesia, hybrid rice seeds are mostly bred in West and East Java,

as these regions have adequate irrigation infrastructure. This also means that only a limited amount of hybrid rice seeds can be grown. Production of hybrid rice seeds is also more expensive compared to inbred rice: according to industry estimates to produce 1 kg of hybrid rice seeds costs Rp 15,057 while it costs only Rp 1,766 to produce 1 kg of inbred rice seeds (Corteva, 2019).

The complicated development and breeding process, limited production and land available, have resulted in high prices for hybrid rice seeds. However, hybrid rice still allows farmers to maximize yields of their rice fields. Hybrid rice has been shown to give higher yields compared to the inbred rice commonly planted by farmers. The following graphic (Figure 4) shows a comparison of the yields of five commonly used inbred rice varieties and five hybrid rice varieties.

> Hybrid rice has been shown to give higher yields compared to the inbred rice commonly planted by farmers.

Figure 4.
Comparison of The Productivity of Inbred and Hybrid Rice Varieties (tonnes/ha)



Source: Processed from rice variety datasheets (BB Padi, 2018)

In a hybrid rice symposium held in Yogyakarta in 2018, International Rice Research Institute Deputy Director-General Bruce Tolentino stated that "When grown under ideal conditions and with sound application, hybrid rice can generate up to 20% higher yields" (IRRI, 2018). The potential yield increase of hybrid rice, in the range of 20 – 30 percent, has been shown in the experiences of India, Bangladesh, the Philippines and Vietnam (Singh et al., 2015, Kanak Pervez et al., 2017, Litonjua et al., 2017, Hossain, 2003).

HYBRID RICE IN INDONESIA

The first commercially available hybrid rice varieties in Indonesia were released in 2003 (Satoto and Suprihatno, 2008), and new varieties were continually developed by BB Padi, as can be seen in Table 1.

In order to provide a comparison of the practices to achieve the most productive utilization of village treasury land, CIPS researchers conducted field research in five villages in Central Java in 2019. The results are described below.

Table 1.
Characteristics of hybrid rice varieties released by BB Padi 2002-2019

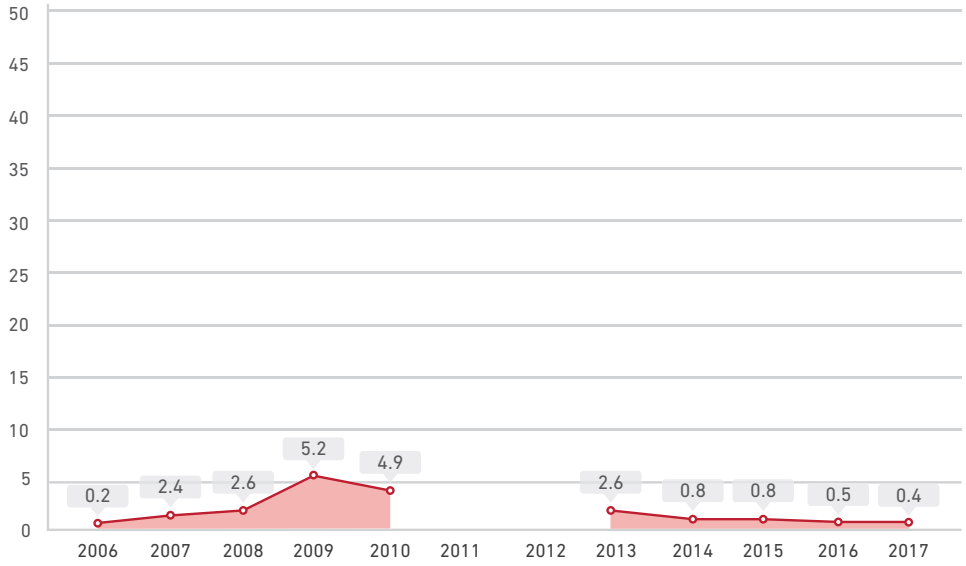
Variety	Year of release	Resistance to:			Average Yield (tonnes/ha)
		Brown planthopper	Bacterial leaf blight	Rice blast	
Maro	2002	-	-	-	6.24
Rokan	2002	-	-	-	6.44
Hipa 3	2004	+	+	-	7.90
Hipa 5 CEVA	2007	++	-	-	7.29
Hipa 8	2009	-	+	-	7.50
Hipa 9	2010	-	+	-	8.10
Hipa 12 SBU	2011	+	+	-	7.70
Hipa 14 SBU	2011	+	+	-	8.40
Hipa 18	2013	+	+	-	7.80
Hipa 19	2013	++	-	++	7.80
Hipa 20	2019	++	++	+	9.54
Hipa 21	2019	++	++	+	8.99

- Low resistance + Moderate resistance ++ High resistance

Source: Satoto (2019)

Yet, the adoption of hybrid rice in Indonesia has been very low (Figure 5). Hybrid rice acreage expanded between 2006 and 2009, rising from 0.2 percent to 5.2 percent of the total rice planting area. This corresponded with the government's program of hybrid rice seed subsidies. However, this figure stagnated and declined in the following years; by 2014 hybrid rice acreage was below 1 percent of the total rice plantation acreage, which continues until the present day (Sudaryanto, 2018; Ansori, 2018).

Figure 5.
Hybrid Rice Planting Area in Indonesia 2006-2017
(as percentage of total rice planting area)



Source: 2006-2010 data processed from Ashari and Rusastra 2014
2011-2012 data not available
2013-2017 data processed from Sudaryanto 2018

Several experts have attempted to identify the causes of the reluctant adoption of hybrid rice in Indonesia (Satoto and Suprihatno, 2018, p. 38; Samaullah et al., 2006; in Ashari and Rusastra, 2014; Sumarno, 2007; in Ashari and Rusastra, 2014). These include, among others: limited production and low availability of parental stock and hybrid seeds, vulnerability to diseases, taste/texture of cooked rice, high price of seeds, farmers' habit of using own seeds, and lack of skills, and contributing IDR 43 million to the BUMDes in rental payments.

New hybrid rice varieties provide solutions for some of these issues. While the initial varieties of hybrid rice from 2002 were vulnerable to a number of diseases and pests, for instance, the most recent varieties claim to be either highly or at least moderately resistant. Moreover, the parental stocks of the hybrid rice were selected to create a taste and texture that suit the preferences of the majority, though not all Indonesian consumers.

"While the initial varieties of hybrid rice from 2002 were vulnerable to a number of diseases and pests, for instance, the most recent varieties claim to be either highly or at least moderately resistant. Moreover, the parental stocks of the hybrid rice were selected to create a taste and texture that suit the preferences of the majority, though not all Indonesian consumers."

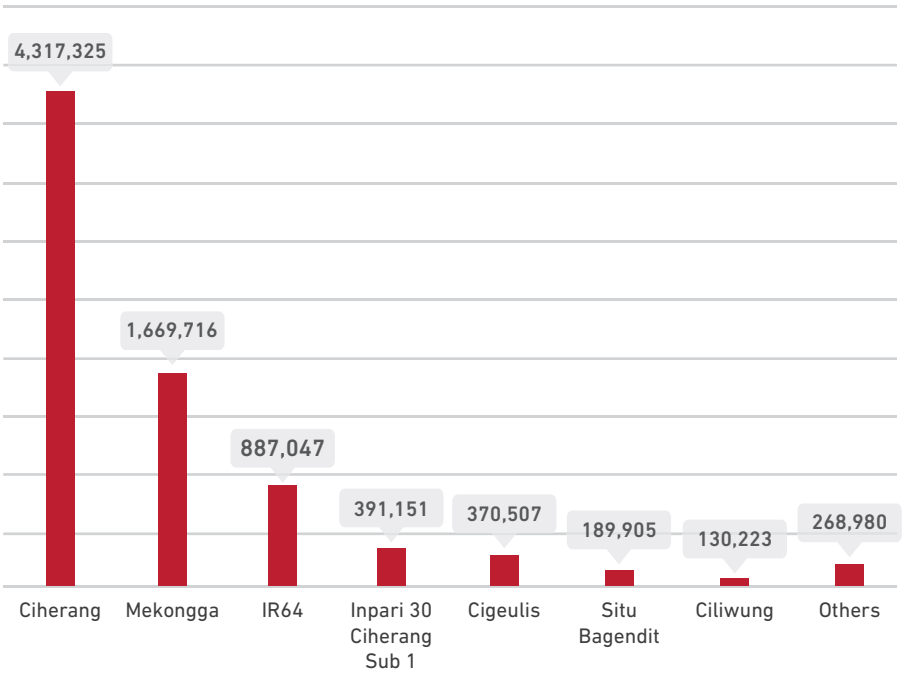
While Indonesians generally prefer moderately soft rice (*pulen*), halfway between the hard-textured rice preferred by South Asians and the very soft and sticky rice preferred in Japan, there are regional differences within Indonesia (Mardiah et al., 2016). The texture of rice depends on the amylose content: the higher the amylose content, the chewier. In Java, the preferred rice is moderately soft and as Java has the largest population in Indonesia, the hybrid rice varieties tend to cater to Javanese consumers (Setyowati and Kurniawati, 2015). However, in Sumatra, the people tend to prefer chewier rice, especially in the North and West. In Kalimantan, the Western parts of the island prefer chewy rice but as one goes East, the preference changes to

With such diversity in Indonesian taste buds, it becomes apparent that a large variety of rice seeds are required, and no single variety can suffice to satisfy demand.

softer rice (Koesrini, Darsani and Rina, 2018). In Sulawesi, Nusa Tenggara and Papua, the softer texture is generally preferred (Untari and Widyantari, 2013).

With such diversity in Indonesian taste buds, it becomes apparent that a large variety of rice seeds are required, and no single variety can suffice to satisfy demand. Indeed, the *Ciherang* inbred rice, which is the most popular variety, can only achieve a 22.9 percent market share in Indonesia (Figure 6). The rest of the market has to be shared with other rice varieties. Given this situation, hybrid rice may offer not only increased productivity, but certain varieties may be suitable to fulfill the taste preferences of local consumers.

Figure 6.
Distribution of Certified Inbred Rice Varieties in Indonesia in 2016
(in hectares)



Source: Processed from rice varieties distribution maps (BB Padi, 2016)

Farmers who tried planting hybrid rice appear generally satisfied with the quality of the seeds. In Central Lombok/West Nusa Tenggara Province, a farmer group using Mapan P-02 seeds claimed an increase in income of up to thirty percent compared to inbred seeds (Fahmi and Nurmat, 2019). This increase is in line with industry estimations that hybrid rice raises rice farmer net revenues by Rp 5 million per hectare per harvest, compared to additional expenses of Rp 1,155,000 for seeds and milling.

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In Subaktalen Village in Tabanan District, Bali Province, 85 percent of farmers have adopted hybrid rice, facilitated by the traditional farmer cooperative (*subak*) system. The farmers uniformly used Mapan P-05 variety and yields met their expectations but they complain about the limited availability of seed supplies. Due to unavailability of hybrid seeds, many farmers were forced to return to planting inbred seeds, as they could no longer find the appropriate seeds in their local market (Liputan 6, 2018).

Despite the high price of hybrid rice seeds (Rp 110,000 - 135,000), farmers do not necessarily consider the price an obstacle. Farmers usually make careful calculations before planting. When they believe that spending more capital on farming supplies will bring them higher revenues, they are willing to do so. In other words, farmers are willing to pay premium prices for hybrid rice seeds when they believe they will gain higher revenues at harvest.

Farmers who cooperate in groups can even lower their costs and purchase seeds at lower prices. If bought in bulk, packets of hybrid rice seeds that usually cost Rp 115,000 can be purchased at Rp 98,000 per kg (Fahmi, 2019). Farmer groups that are willing to invest in hybrid rice seeds generally consist of younger, so-called 'advanced farmers' (petani maju) who are more responsive towards new farming methods, apply new technology and are not averse towards trying new products.

One of the main problems faced by hybrid rice farmers is the lack of sufficient seed supplies. Industry experts estimate that, on a given plot of land, a breeder can produce up to four times as many inbred rice seeds than hybrid rice seeds; 6 tonnes/ha compared to 1.5 tonnes/ha. A breeder in Subang reported that he produces 3-4 tonnes of hybrid rice seeds per hectare on a plot that normally yields 6 tonnes of inbred seeds (Sarkam, 2019). The relatively low yield of hybrid rice seeds is due to the need of planting R plants on the plot. These yields are not counted in the hybrid rice seed production. In some cases the R plants are removed before their seeds can mature (Leksana, 2019). In West Java, seeds of the R plants are allowed to mature and the seeds become the property of farmers (BB Padi, 2019).

"One of the main problems faced by hybrid rice farmers is the lack of sufficient seed supplies."

The number of breeders capable of breeding hybrid rice seeds is limited; and some breeders can only produce 100 tonnes of hybrid rice seeds in one season (Satoto, 2019). In fact, the total production of hybrid rice seeds in Indonesia does not exceed 500 tonnes/season. As a result, there is a shortage of hybrid rice seeds, and the price of available seeds rises. While the reference price of hybrid rice seeds is Rp 70,000 per kg (Sang Hyang Seri, 2017a; 2017b), the actual price that has to be paid is far higher, between Rp 110,000 and 135,000 (compiled from interviews, 2019). This has to be compared with the typical price of high quality inbred rice seeds, which is about Rp 10,000 to 25,000 (Tirto, 2016).

Considering the need for a large increase in domestic rice supplies, a lot remains to be done by the government, the private sector, and the farmers to increase the adoption of hybrid rice by a larger number of farmers in Indonesia.

GOVERNMENT POLICIES AND PROGRAMS

The government sector is not a singular actor; it includes relevant agencies on the ministerial level (Ministry of Agriculture, National Planning Ministry/Bappenas, and the Ministry of Finance), local government offices, as well as the researchers in the government research institute developing hybrid rice (BB Padi).

A. Prioritizing Hybrid Rice Development

> "Hybrid rice is indeed not included in any major programs related to agricultural development planning in the National Medium Term Development Plan/RPJMN"

There appears to be a disconnect between the different government levels as Bappenas does not prioritize hybrid rice development. Instead it seems to pay more attention to the development of rice fortified with minerals (BB Padi, 2019). Hybrid rice is indeed not included in any major programs related to agricultural development planning in the National Medium Term Development Plan/RPJMN (Rusono, 2019).

The reason might be that the quantity of national rice production in Indonesia has long been overstated. This has only of late been corrected using the Area Frame Sampling Method (Ruslan, 2019). With official statistics showing adequate levels of rice production, policymakers are not pressured to focus on increasing productivity, resulting in inadequate attention towards hybrid rice development.

It is therefore not surprising that the government does not have a significant program to increase the acceptance of hybrid rice by farmers. At the village level, for example, there are no extension services provided by the government to educate farmers about hybrid rice; it is up to private companies and the farmers themselves to provide knowledge about hybrid rice.

B. Providing Hybrid Rice Seeds

In the past, the government used to provide hybrid rice seed subsidies but the program failed to permanently encourage farmers to plant hybrid rice (Nurasa and Supriadi, 2012). This has been due to the nature of the program, in which farmers were provided with a single variety of seeds, regardless of the appropriateness of the seeds to the local climate, water supply, planting season and a plethora of other factors influencing the success of a crop. While the subsidy did not give farmers significant increases in their income, they, in fact, experienced losses due to crop failures (Ashari and Rusastra, 2014).

Farmers generally do not believe that subsidies in kind are appropriate to optimize production. Instead of providing subsidies in kind, the government can choose to provide subsidy vouchers, which can be utilized by farmers to purchase whatever farming supplies they need. The government currently plans a Farmers Card *(Kartu Tani)* program (Nurmat, 2019), which allows the farmers to acquire necessary supplies. The card opens the market and also improves competition among the private sector: rather than appointing one company to provide a large amount of supplies, many companies provide different varieties that suit different conditions.

C. Hybrid Rice Seeds at Subsidized Prices

In several countries, including Indonesia (Nurasa and Supriadi, 2012), there have been government attempts to increase adoption of hybrid rice by providing price subsidies on hybrid rice seeds. It appears, however, that farmers respond by adopting hybrid rice only as long as the price is subsidized. When the subsidy is withdrawn, their interest is lost. This has been the case in Indonesia (Ashari and Rusastra, 2014; Sudaryanto, 2018), Vietnam (Tran and Nguyen, 2009) and the Philippines (Bordey et al., 2016).

Since the early 2000's the Filipino government promoted hybrid rice with subsidies and the adoption of hybrid rice jumped significantly. When the subsidies were considered too costly for the government and these were withdrawn, the hybrid rice acreage and production declined again. It was only at the beginning of 2011, when the private sector became more involved in developing hybrid rice varieties through partnerships with local seed growers, that the trend was reversed and production increased again (Bordey et al., 2016). It was found that Filipino seed growers were able to produce F1 hybrid rice seeds with a unit cost of US$ 1.2/kg, comparable to India at US$ 1.0/kg and at much lower costs than China (US$ 1.6/kg). They sold their hybrid seeds to farmers at a price of US$ 1.71/kg (Bordey et al., 2016). This has stimulated the seed growing business in the Philippines, with positive implications for the availability and price of seeds, which in turn increased the adoption of hybrid rice by farmers.

D. Import of Hybrid Rice Seeds

The government also maintains regulatory interventions in the hybrid rice market. Article 5(1) b of MOA Regulation 127/2014 on the Introduction and Release of Seeds states that F1 hybrid rice seed imports are allowed for a three-year period after the release of the variety. However, several companies have found themselves unable to conduct imports. According to Article 10 of the Regulation, such imports are conditional on the insufficient supply of domestic seeds but there is no explicit differentiation between inbred and hybrid seeds. As a result, the government can block F1 imports arguing there is no shortage of domestic seeds.

Importing new hybrid rice seed varieties can be highly beneficial as the experience in Vietnam demonstrates. There, the private sector developed seeds from Chinese parental seeds that were considered suitable for planting in the central and northern regions of Vietnam, which are having similar conditions like Southern China, where the seeds were designed. 80 to 90 percent of hybrid rice seeds planted in Vietnam were imported from China (Tran and Nguyen, 2009). This policy of opening the markets to imports resulted in an increase of hybrid rice acreage to 14 percent of the total rice planting area in 2013 (Tran and Vu, 2016).

In Indonesia, a newly revised Plant Cultivation System Bill is currently being discussed in National Parliament (Sa'diyah, 2017). This law acknowledges the role of the private sector, explicitly allowing the private sector (business actors) to conduct seed imports in Article 22(3) and Article 25(1) and (2); the existing Law does not provide such recognition. However, the new Bill still restricts such imports to situations when seeds are not available domestically (Article 26). This article should be removed to prevent the current situation from reoccurring in the future.

E. Financial Support for Hybrid Rice Farms

Loans are quite a common tool by the government to support the local economy. Farmers who understand the benefits of high-cost-but-high-yielding farming supplies are willing to spend more money to obtain higher yields. These farmers could receive financial support if the microcredit scheme KUR (*Kredit Usaha Rakyat*) is expanded to include farmers. The KUR program provides maximum loans of Rp 500 million at a subsidized interest rate of 7 percent. These loans are to be repaid in monthly installments for a maximum duration of 36 months for capital. While this may be appropriate for farmer groups and farmer cooperatives, as they can have multiple crops in one period, however, there is a risk that individual farmers loose their entire livelihood as the business or object being financed by the credit has to serve as collateral (CMEA, 2018; Yayasan IDH, 2018).

An alternative financing system is the public agency model BLU (*Badan Layanan Umum*). In the Ministry of Agriculture, the BLU model has finished its academic study and has been delivered to the Ministry of Finance for further consideration (Sinar Tani, 2018). BLU offers loans at an even lower interest rate and the payment schedule is to be made in accordance with the harvest cycles (between 3-6 months) (Yayasan IDH, 2018). Only farmer groups that have been legally registered as a corporate entity (*badan usaha*) are eligible to receive a loan. Additionally, as the process of borrowing involves supervision and advice by government extension agents, farmers would receive technical assistance and skills necessary for planting hybrid rice.

F. Extension Services

Extension services (*penyuluhan*) by local offices of the Ministry of Agriculture (*Dinas Pertanian*) are part of the SL-PTT (Integrated Crop Management Field School) program that provides farmers with the skills necessary to increase the yield of their rice crops, including hybrid rice. The SL-PTT was criticized in the past for its central design providing uniform allocations of seeds and fertilizer regardless of local conditions (Nurasa and Supriadi, 2012). A suggested way to improve the implementation of this program is that the offices work in partnership with local seeds growers to provide adequate supplies of seeds that are suitable to local conditions. It has also been identified that the field instructors' knowledge of the program was limited and there was a lack of knowledge of supporting techniques (Nurasa and Supriadi, 2012). It is, therefore, recommended for the government to work with the private sector, particularly companies developing hybrid rice seeds, which are able to provide instructors with adequate knowledge about the optimal utilization of hybrid rice seeds.

When farmers engage in groups they can obtain farming supplies at lower prices and their numbers also make it more also more attractive for companies to provide appropriate extension support. This is the case in Lombok, where farm supply manufacturers provide extension support from planting to harvest. The private sector benefits from educating the farmers on seeds, pesticides, fertilizers, supplements etc. when satisfied farmers become repeat customers. Traditionally, farmers use part of the harvested rice as seeds in the following season. Farmers are tempted to try this with hybrid rice but it cannot be done and it results in disappointingly poor yields (Fahmi, 2019). Similarly, in order to achieve optimal results, farmers need to use adequate pesticides and fertilizer in accordance with the seed producer's suggestions. Hybrid rice also requires more fertilizer compared to inbred rice due to the higher fecundity of the plant. Farmers may try to cut the amount of necessary farming inputs but, in the end, they see the yields fall below their expectations.

When farmers have the proper skills to plant hybrid rice, they find it highly valuable. The hybrid rice used by farmers in Lombok brings more yields (10.4 tonnes/ha) compared to the inbred rice varieties they generally use (max. 8 tonnes/ha). The additional yield translates into an extra Rp 10,000,000 of net revenues (after input costs and post-harvest expenses) per hectare per year.

G. Hybrid Rice Research and Development of New Varieties

Besides providing financial incentives and technical assistance to farmers, the Indonesian government needs to also improve hybrid rice research capacities in Indonesia. Despite the potential offered by hybrid rice to increase rice productivity, the number of persons engaged in hybrid rice research is severely limited. BB Padi currently has four researchers, and they are doing research in hybrid as well as inbred rice varieties. In China, by contrast, there are rice research institutes across the country, resulting in a network of universities and research centers involving hundreds of researchers (Li et al., 2009; Satoto, 2018).

Rice research in Indonesia is centralized in the Indonesian Agency for Agricultural Research and Development (IAARD) of the Ministry of Agriculture. The IAARD in Bogor oversees the work of the Indonesian Center for Food Crops Research and Development, which, in the area of rice-related research, coordinates the work of the Indonesian Center for Rice Research, located in Subang, West Java, and the Tungro Diseases Research Station in Lanrang, South Sulawesi. The research station in Sulawesi has the potential to become the nucleus for a regional rice research institute for Eastern Indonesia in cooperation with the Hasanuddin University in Makassar, South Sulawesi. If these local state universities cooperated with the private sector they could provide scholarships and train agricultural students (ICFORD, 2015).

The experiences of China illustrate how the private sector can be constructively involved in increasing hybrid seed yields. Both, government rice research centers and private corporations, e.g. Long Ping High-Tech and Hefei Fengle Seed Co, have been active in developing hybrid rice research, particularly techniques for efficient seed production (Yuan, Deng and Liao, 2004). The increased seed production in China has resulted in lower prices of seeds, benefiting farmers, and facilitating the expansion of hybrid rice acreage in the country (Zhou and Peng, 2005). Between 1976 and 2008, hybrid rice yield jumped from less than 400 kg/ha to almost 8 tonnes/ha (Li et al., 2009). This corresponds with the dramatic increase in the rice production of the country in the same period, as well as the increase in the land area planted with hybrid rice. By 2013, more than 50 percent of the total rice acreage in China had been planted with hybrid rice. Pakistan also expects to increase the hybrid rice acreage from 25-30 percent in 2018 to reach 50 percent of the total area planted with paddy in 2021, mainly in cooperation with the Chinese seed company Guard Agri (Seedworld, 2018).

Quantity alone is not sufficient to make hybrid rice a success but developers of hybrid rice need to also focus on the quality of the rice commodity. As stated earlier, it is important for hybrid rice to accommodate consumer preferences for taste and texture. Initially the acceptance of hybrid rice by consumers in Bangladesh (Husain et al., 2001), India (McFall et al., 2013) and Vietnam (Hossain et al., 2003), as in Indonesia (Ashari and Rusastra, 2014) was lacking. Farmers were driven to inbred rice varieties that were in higher demand (Husain et al., 2001; McFall et al., 2013; Hossain et al., 2003).

If hybrid rice is meant to be planted on a larger scale in Indonesia, there is a need for continuous research and the development of new hybrid rice varieties that correspond with local preferences and growing conditions. The private sector plays a pivotal role with its technical expertise and financial capacities to develop new hybrid rice varieties. Several companies have been active in marketing hybrid rice seeds in Indonesia. PT DuPont Indonesia (part of Corteva Agriscience) developed three hybrid rice varieties (PP1, PP2 and PP3) and received the license to produce two other varieties developed by the government (DuPont, 2019). PT Bayer Indonesia sells *Arize H6444 Gold* and *Arize Prima* hybrid seeds (Bayer, 2017). PT Biogene Plantation sells *Sembada* hybrid seeds, and PT Primasid Andalan Utama imports seeds and sells them under the *Mapan* brand.

Following China's example, with more supplies and varieties being developed and bred in Indonesia, it can be expected that seed imports become less relevant and Indonesia can, in turn, become a center of excellence that exports seed varieties to neighboring countries with comparable planting conditions.

More supplies of seeds are also expected to lower seed prices. Hybrid rice anyway requires less seeds for planting, due to the higher germination rate of hybrid seeds compared to inbred seeds (80 percent to 50 percent) (Hossain, 2003). Therefore, farmers need to buy fewer seed packets to plant a given plot.

If household consumption of rice remains limited due to consumer preferences, crops can also be produced to fulfill industrial demands. Inbred varieties, such as Kapuas, are suitable for baby food, *Cisokan* and *Mahakam* are used for canned rice and *Jatiluhur* as well as *Progo* for rice noodles. *Gilirang* and *Sintanur* are highly aromatic, while Mamberamo is favored by the export market (Nugraha and Sayaka, 2004). Similarly, hybrid rice developers also need to produce varieties with comparable characteristics so that farmers can increase their rice productivity for industrial purposes.

PRODUCTION CONSTRAINTS AND OTHER ISSUES FACED BY THE PRIVATE SECTOR

In Indonesia, several companies have been active in producing and marketing hybrid rice seeds. Some of these companies have the capability of developing hybrid rice varieties themselves, while others import the parent stocks to produce seeds locally (Leksana, 2019). Additionally, the private sector acquires licensed varieties from BB Padi and produces them commercially, released under their own label. This has been done by DuPont/Corteva and Bayer, for example. The following Table 2 shows the hybrid rice seeds currently or recently available in the Indonesian market.

Table 2.
Characteristics of hybrid rice varieties released by BB Padi (2002-2019)

Company	Hybrid seed trade name	Notes
Du Pont (Corteva)	PP1, PP2, PP3, PP4	Imported from India
Bayer	Arize H6444 Gold, Prima, 86	Arize 86 is licensed from BB Padi's Hipa 20
Biogene	Sembada 89, 68, 188, 989	
Primasid	Mapan P-02, P-05	Parents imported from China
BISI	Intani 301, 602	
Petrokimia	Petro Hibrid	Licensed from BB Padi's Hipa 19
Padi Hibrida Nusantara	Segara Anak, Brang Biji	

Source: DuPont (2019); Riedha (2017); BB Padi (2019)

BB Padi, as a government research agency, develops hybrid rice varieties but it is not their responsibility to produce the seeds commercially. BPATP (Center for the Management of Agricultural Technology Transfer), is the government agency appointed by MOA Regulation 1/2006 to work with those private actors who wish to acquire licensed varieties developed by BB Padi or cooperate in the development of new varieties. For example, Bayer cooperated with BB Padi in selecting and developing the variety that was later released as Arize 86/Hipa 20 (BB Padi, 2019).

The problem with hybrid rice seeds is not acceptance *per se;* conversely, the issue is perceived as a lack of production capacity. The companies are confident to find markets for their products, however, they can only provide relatively small amounts of seeds per year, resulting in farmers

being put off because they have to find alternatives in the following season. Moreover, seeds can only be produced optimally in a short period of time, and only a small number of farmers have the requisite skills training to breed rice seeds.

Various types of rice growing conditions require different varieties of rice. Rice is classified as paddy rice, rainfed rice, upland rice and wetland rice, based on the amount of water required (or tolerated) for its growth (Wahyuni, 2017). In some climate conditions, crops have to mature before the onset of the dry season, meaning that shorter maturing varieties are required. Also, different locations have different pests and diseases: leaf blight, blast, insects, and microbial infections. Additionally, chemicals such as aluminium, iron, salt and glyphosates are tolerated differently by different varieties (Wahyuni, 2017). As a result, there is no 'one size fits all' hybrid rice variety that can be planted in all conditions. With limited research capacities of BB Padi, the private sector needs to support the research and development required to create new varieties that are well-adjusted to local conditions, or at least import the varieties that are known to be so. Imports of specialty hybrid seeds is also economically more viable for specific requirements where local conditions are unique enough to demand certain qualities of seeds that maybe be found elsewhere.

As an example, a farmer group in Lombok finds Primasid's Mapan P-02 especially suitable for the climate and planting conditions in the area; however, Primasid is currently focusing its production on Mapan P-05 (Sarkam, 2019; Fahmi, 2019). As a result, the farmers have to find alternatives other than hybrid rice.

Another concern of the private sector are government seed subsidies which force companies to compete at a reduced price, meaning they have to cut costs by using lower quality varieties (Leksana, 2019). Farmers then find the seeds less than optimal and no longer trust even the unsubsidized products of the company. This weakens the market, and reduces the ability of the private sector to develop and market new varieties. In some cases, farmers were reported buying subsidized seeds and reselling them under the label of high quality non-subsidized hybrid seeds (Leksana, 2019). This further undermines markets for high-quality hybrid seeds. Seed subsidies, if applied at all, should only target less developed regions in order to encourage the transition to hybrid rice. Advanced farmers who receive their supplies from seed companies do not need subsidies (Sayaka, 2019).

The restrictive import practices that were mentioned earlier constrain the business of hybrid rice. Indonesia is a large country with different farming characteristics (location, season, water supply etc.); importing small numbers of seeds that are suitable for certain locations is a more viable rather than having to develop multiple varieties domestically. In the bigger picture, seed imports are necessary to maintain a stable supply of seeds in the market, and providing farmers with different varieties that are suitable for different conditions. Most of all, imports are necessary to fill the shortage of the current national demand – current production levels are claimed to fulfill only 10 percent of the demand (Satoto, 2019). For example, PT Petrokimia Gresik is only able to supply 100 tonnes of rice seeds in a year, as they have only a limited number of partner seed growers; the company does not import any of its seeds or parent stock (Tirto, 2016). While addressing limited domestic production by increasing cooperation with breeders is the only sustainable solution, imports should provide more seeds of different varieties.

In order to safeguard farmers and ensure that released varieties are in fact appropriate to Indonesian conditions, each new variety has to undergo a lengthy process of certification through field-testing in eight locations. The process, comprising of planting the parental stocks (4 months), planting the F1 seeds (4 months), data processing (6 months), and the lab report (2 months), takes about 16 months. It can take even longer depending on the field conditions and other variables. The Food Crop Variety Release Team then conducts a verification process, usually twice a year, and the Center for the Protection of Crop Varieties and Permits finally releases the variety, which on average takes another 5-6 months (Riedha, 2019). The entire process is longer and more complex than stipulated in MOA Regulation 40/2017. Uncertainties in this process cause challenges for the marketing teams of seed distributors because hybrid rice seeds have sell-by-dates of only 6 months (Riedha, 2019). Streamlining the process, from certification to release, allows the private sector to access markets earlier and reach a greater number of customers.

CONCLUSION AND RECOMMENDATIONS

Hybrid rice improves the situation of rice farmers and consumers alike. For farmers, hybrid rice potentially increases their net revenues from about 15 to 20 million Rupiah per hectare. It also exposes them to modern technologies. The consumers benefit because increased domestic productivity will ultimately bring down domestic rice prices (app. Rp 12,000/kg) that are currently about twice as high as on world markets (app. Rp 6,000/kg). This is of particular importance as the surging demand for rice will most likely cause further rice price increases in Indonesia. Poor households will benefit most because they spend between 50 and 70 percent of their income on food. This includes two thirds of all Indonesian subsistence farmers, who are also net consumers of food. On a macro level, productivity increases due to hybrid rice will calm the price swings caused by low supplies of rice and, therefore, improve food security in Indonesia.

Hybrid rice is being developed in Indonesia and the currently available varieties are far better than the earliest ones, in terms of productivity, disease resistance, weather resistance and taste/texture. However, hybrid rice has not been accepted in large numbers. In order to change this condition, the stakeholders of hybrid rice: the government, the private sector and the farmers, have a lot to work on, not just in improving the hybrid rice varieties, but by improving policies, research and farming practices.

Government policymakers on all levels should give priority to hybrid rice. Because of its importance in the greater scheme of food security, it must become a priority in the policies pertaining to rice production.

Imports of parental stock are needed to facilitate sustained supplies of hybrid rice in Indonesia. Article 5(1)b of MOA Regulation 127/2014 on the Introduction and Release of Seeds states that F1 hybrid rice seed imports are allowed for a three-year period. However, several companies have found themselves unable to conduct imports because Article 10 of the Regulation makes imports conditional on the insufficient supply of domestic seeds. Likewise, Article 26 of the newly revised Plant Cultivation System Bill also limits imports to situations when seeds are not available domestically.

The Ministry of Agriculture should refrain from providing free hybrid rice seeds or seeds at subsidized prices as short-term methods to increase hybrid rice acceptance. International experiences have not proven this to be a sustainable and effective method. Instead, vouchers could be considered that can be utilized for a range of farming inputs by the farmers. These vouchers can take the form of a Farmers Card, similar to other non-cash vouchers already implemented.

The wide range of soil and climate characteristics as well as consumer preferences make it impossible to develop a ‘one size fits all’ type of hybrid rice. Imports of hybrid rice seeds should be recognized as a short-term necessity to provide varieties that may be suitable to particular conditions in certain parts of Indonesia. This should be done in partnership with the private sector, especially corporations that may already have suitable parental stock for release or for further development, both multinational and local corporations.

In order to reduce the dependence on seed imports, the government should incentivize local universities to develop new hybrid rice research centers, as well as the required human resources. In the long run, only a continuous pool of researchers will be able to sustain and expand the development of hybrid rice in Indonesia. Local research centers across the country should work on developing varieties that suit the consumer preferences as well as climate and soil conditions in different areas of Indonesia.

The private sector should work closely with farmers to assess their needs and demand. Equally important is that the private sector continues to engage in technical extension programs for Indonesian farmers who need to learn the skills of growing hybrid rice varieties.

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