Village Seed Production Groups Supported by Network and Capacity Building in Disseminating Modern Varieties in Indonesia

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Abstract. Strategic food crops production such as rice, maize and soybean are determined by harvested areas multiplied by productivity, while productivity is affected by availability of highquality seed of modern varieties which is adaptive to both biotic and abiotic stress. This study aims to construct a nationwide network and capacity building in supporting village seed production groups (VSPGs) for disseminating modern varieties to increase productivity. VSPGs constructed based on community seed system in corresponding to the national seed system and supported by breeder seed management unit network between national research institutes and assessment institute of agricultural technology. The seed production was implemented by a VSPGs on farmer field school with field laboratory 3-4 ha to introduce new modern varieties and quality seed production at once. The seeds of the available varieties in-situ 44 adopted 19 of the 133 varieties for rice, while the maize seeds available 8 were adopted 5 out of 86 varieties, and for soybean seeds there were 14 and adopted 7 of the 17 varieties released in the last 12 years. Acceleration in-situ seed provision can be pursued through integrated seed supply network, capacity building and market access to speed up and adoption of modern varieties. Keywords : Village, Groups, Capacity, Disseminating modern, Indonesia.

1 Introduction

Indonesia's food demands continue to increase in line with the increasing population [1]. Relying on imports to meet national food needs is considered risky, so efforts to increase domestic food production must receive serious attention [2]. On the other hand, the demand for staple food must be met from the decreasing area of rice fields and the direct and indirect impacts of climate change on food production [3].

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Increasing the production of food crops, especially rice, maize, and soybeans, is determined by harvested area, increasing productivity, and minimizing post-harvest loss [1]. The expansion of the harvested area and the increase in crop productivity is influenced by climate change [3], while the increase in productivity is determined by the genetic superiority of the variety (G), the growing environment and crop cultivation management (M) [4]. Quality seeds of modern varieties with genetic purity and vigour affect 20-40% increase in plant productivity [5].

The use of rice, maize, and soybean certified seeds of modern varieties (MVs) in 2016 from government subsidy and free market for rice is 43.64% of the total potential need for seeds of 415,711 tons, maize 47.20% of the potential needs of seeds 98,011 tons and soybean 47.90% of the need for 26,809 tones, respectively [6]. The use of low quality self-produced uncertified seeds needs to be reduced therefore the genetic potential of varieties can be actualized.

The adoption of MVs of rice, maize and soybeans dominates the planted area compared to local varieties in 2011-2017 [6]. MVs of rice were adopted at 88.72% of rice planted area in a year which reached 14.3 million ha. Ciherang, Mekongga, Cigeulis, IR-64 and Situbagendit varieties were adopted 62.41% of the total planted area. MVs of maize were adopted at 83.32% of the total planted area of 4-5 million ha in a year. Hybrid maize varieties including Bisi-2, Bisi-16, P-1, P-12, Bisi-816 and Bisi-222 were adopted in 27.71% of the planted area. In the same period the soybean varieties Anjasmaro, Wilis, Grobogan, Orba, Baluran, Kaba, Burangrang and Mahameru were adopted in 70.4% of the soybean planted area in a year, reaching 0.6-1 million ha. The Wilis variety spreads over 35.2% of the planted area, being the most popular soybean variety.

Empirical data show that commercial seed producers only multiply the seeds of varieties that have a market preference already, while the newly released MVs seeds were not available in the market, so farmers cannot plant them. The current formal seed production and distribution sub-system is not conducive to the dissemination of location specific MVs.

Informal seed systems are very important access for farmers in African countries to get the variety seeds they need [7]. One step towards realizing the provision of in-situ seed should begin with developing integrated formal and informal seed system and increasing the capability to produce good quality seeds of adaptive varieties which matched with customer preferences. Experience in developing community-based seedlings in the Cameroon highlands shows that MVs seeds can be obtained easily, on time, are of good quality, and at affordable prices [5]. The development of a national network of integrated seed production systems is expected to be a solution to increase the ability of farmers or farmer groups to produce quality seeds in-situ according to consumer preferences. This paper aims to describe efforts to develop an integrated seed system network between community-based seed systems and formal seed systems as well as to increase their production capacity and hence they can produce quality seeds of MVs autonomously and sustainable to stimulate adoption.

2 Materials and methods

2.1 Research, breeding, and release of varieties

The scope of research and breeding of the national seed system (NSS) includes the use of domestic genetic materials and foreign introductions to breed a new MVs, as well as the
production of seeds through several stages of the nucleus seed (NS) class to the extension seed (ES) for the farmers.

The results of breeding activities after going through several stages of selection and testing resulted in promising lines. Promising lines that have gone through the multi-location trials can be proposed to the Minister of Agriculture (MOA) to obtain a Decree of the MOA as a new released variety. Adaptation testing can be carried out by breeders, the Regional Seed Monitoring and Certification Centre (RSMCC) or the private sector. Varieties that have received a decree from the MOA can be produced and traded legally. Seeds from introduced varieties are required to undergo multi location trials prior to being proposed to the MOA. A local indigenous variety can be registered after going through the purification process.

2.2 Seed production and distribution

Production and distribution of seeds go through several stages of seed classes before distributing to farmers. NS produce only by breeder; however, breeder seeds (BS) are produced not only by breeders, but also by government agencies, and the private sector or individuals. Seed derivatives, hereinafter referred to Foundation Seed (FS) and Stock Seed (SS), are produced by Provincial Seed Centers, Regency Seed Centers or Seed Producers. ES is a seed class that is ready for use by farmers, produced by seed producers. Hybrid F1 seeds of rice and maize are considered as ES. The seeds of legume and tuber crops can be propagated through a multiple seed propagation pattern.

Quality assurance of seeds through certification for all seed classes is carried out by the RSMCC or private sector. Certification of BS and FS can be carried out independently if they have implemented a quality assurance management system and acquired ISO 9001-2015 certificate. The RSMCC is also supervising the distribution of seeds from breeders or seed producers to farmers.

The MOA issued a letter of assignment Number 86 / HK.410 / M / 4/2015 to Indonesian Agency for Agriculture Research and Development (IAARD) to carry out the propagation of quality seeds modern variety of rice, maize, and soybean until December 2019. The assignment letter provides a legal framework for the Breeder Seed Management Unit (BSMU) of Indonesian Assessment Institute of Agriculture Technology (IAIAT) under IAARD to produce FS and SS that are not yet popular while still following the flow of the NSS. The assignment is expected to accelerate the provision of in-situ seeds and encourage adoption. In line with the supply flow of quality breeder seeds, the multiplication of NS-BS to become FS-SS requires synchronization and synergy among NRI, IAIAT and seed producer [8]. Partnership (between Ministries/Agencies and farmers/breeders), Ownership (a sense of belonging to the community/farmers), and Promotion (field exposition) are the keys to the successful implementation of this model [9].

2.3 Community based seed systems

The village seed production group (VSPGs) model was built in 2015 based on the Community Based Seed System (CBSS) developed by the Consortium for Unfavourable Rice Environment (CURE), IRRI [10]. National Research Institutes (NRI) released new modern varieties, mastering seed health management and seed quality management systems, integrated crop management and natural resource management to produce seeds in the technological sub-system. In the process sub-system involves the community to assess the need for seed production, selecting varieties, conducting training and field visits.
Support needed for the development of CBSS is organizing implementation, compiling a business plan related to market possibilities, selecting farmers who are interested in planting or producing MVs seeds according to community preferences and support from the RSMCC to ensure quality, provide a certificate of good quality seeds when distributed to the market.

2.4 Treatments and experimental design

Increasing the ability of VSPGs to produce seeds according to preferences, is carried out by direct practice in an farmer fields school (FFS) from 2016 to 2019 [11]. FFS is a school where the entire teaching and learning process is carried out in the field. Farmers' paddy fields are called the field school (FS) area, while the paddy field where the MVs introduced in 3-4 ha is called the field laboratory (FL). This FS seems to make participating farmers as students and field guides (FG) as teachers. However, in this FFS there is no distinction between teachers and students because the atmosphere is giving each other knowledge based on experience. Seeds used by other groups or distributed by partners need to be registered by RSMCC for seed certification, except for use in their own group.

Through the FFS, it is expected that technology transfer will occur through various stages of training from NRI breeders as resource persons to farmers. Resource persons provide science and technology that has been developed to FG consisting of the Person in Charge for IAIAT activities and NRI researchers as companion activities in training for trainers (TOT) at the national level in accordance with commodities i.e., rice by Indonesian Centre for Rice Research (ICRR), maize by the Indonesian Cereal Research Institute (ICERI) and soybean by Indonesian Legumes and Tuber Crops Research Institute (ILETRI).

The FGs delivered science and technology by guiding the FFS participating farmers. The aim of the FFS is to accelerate the technology transfer of seed production technology from researchers to farmers participating in the FFS and natural diffusion from the FFS to the neighbours, therefore seed production techniques mastered by the farmers all over the area.

2.5 Survey and data analysis

The survey was carried out using a structured questionnaire to find out information on the existing seed production network between NRI-IAIAT, the willingness to produce seeds, how to obtain seeds (ex-post), business plans and implementation, and implementation of seed production activities after the introduction of the model until 2019 (ex-ante). The varieties adoption data were obtained from the Directorate of Food Crops Seed Production based on seed certificate issued by RSMCC in 2019.

Data were tabulated and analysed by description. Based on the sustainability of seed production from 2015-2019, VSPGs were classified as follows: (1) Beginner; Seed production continues only until the first year since program commencement (P + 1); (2) intermediate, seed production continues independently until the second or third year since the start of the program (P + 2 - P + 3); and 3) advance, seed production continues independently, seed production continues until the fourth year since the start of the program (P + 4).
3 Result

3.1 A nationwide seed production network

Using a reference to the CBSS has been developed a network involving the NRI BSMU, IAIAT and VSPGs in coordination with the Agriculture Extension Office (AEO) and the RSMCC in each province to produce good quality of new MVs’ seed (Fig. 1). The production network of rice, maize and soybean seeds is implemented in 24 provinces, 9 provinces and 13 provinces of 26 AIAT nationwide in the 2015-2019 period, respectively. The VSPGs built in each province range from 1-7 units, for a total of 87 units nationwide, with details for 48 units of rice, 14 units of maize and 25 units of soybeans. NRI is an implementing agency for plant breeding that produces new MVs along with BS and FS seed classes. The BSMU of the ICRR, ICERI and ILETRI produce rice, maize, and soybean breeder seed, respectively by implementing ISO 9001-2015 seed quality management assurance system for producing BS and FS seed classes.

Fig. 1. Seed production network and seed production field school.

The IAIAT identifies prospective VSPGs to produce seeds in an area, organizes FFS for seed production and FL of varieties demonstration plot to produce SS class at a minimum area of 3-4 ha. The varieties grown in FL are newly released MVs. NRI supervised the implementation of quality seed production techniques. Prospective VSPGs at the beginning were allowed to multiply seed of MVs released more than 12 years ago (Table 1) inside FL and FFS to meet seed needs. These varieties are favoured by farmers because of their adaptability to agroecosystems and the preferences of the farmers themselves. Previous research showed that farmers’ perceptions are particularly important in determining which variety they will adopt [12-14].

Network and quality seed production capabilities improvement that have been carried out every year from the initiation of 2015 to 2019 include: (1) implement FFS; (2) introduce a business plan; (3) institutional VSPGs and (4) partnerships for seed marketing.

Table 1. The older MVs more than 12 years after released are preferred by farmers
### 3.2 Availability of modern varieties seed in-situ

Through the seed production network from the start of these activities in 2015 to 2019, IAIAI can support the process of adopting food crops MVs by providing seeds in-situ. Based on the results of the seed production network activities during this period, it was known that the seeds of 44 MVs of rice, 8 of maize and 14 of soybeans which were released in the last 12 years were available in-situ. The process of availability of seeds for adoption varied over time, between a minimum of 1 year and a maximum of 11, 10 and 9 years after release for rice, maize, and soybean, respectively (Fig. 2). The adoption of varieties continues until 2019 for 19, 5 and 7 new released varieties of rice, maize, and soybeans, respectively.

![Fig. 2. The time span of modern variety seed production in-situ from the moment of release.](image)

### 3.3 Capacity building for quality seed production ability

The willingness of VSPGs in producing seeds was presented in Table 2. Most of VSPGs (55.6%) showed willingness to produce seeds for their own needs or other farmers in the
same group, the remaining 44.4% were interested in providing seeds for other groups or providing seeds within the framework of inter-field and inter-season seed networks or so called as JABALSIM.

Most of the VSPGs maize seeds (85.7%) wished to produce seeds for their own needs or for other farmers in the same group. More than a half number of VSPGs soybean seed (54.0%) wished to provide seeds for other groups or provide seeds within the framework of “JABALSIM”, some (46.0%) produced seeds for their own needs or other farmers in the same group.

The average certified seed produced by the VSPGs unit in one season were 25,723 kg of rice, 9,149 kg of maize and 11,471 kg soybean, respectively with seed production range per unit between 400 kg - 300,000 kg for rice, 500 kg - 54,400 kg for maize, and 400 kg - 114,700 kg for soybean. The seeds were sufficient to be planted in an area of 1,029 ha for rice, 610 ha for maize and 326 ha for soybeans with considering the need for seeds per ha, respectively, 25 kg. ha-1, 15 kg. ha-1 and 35 kg. ha-1.

Table 2. The willingness of VSPGs in producing seeds in 2015.

<table>
<thead>
<tr>
<th>No.</th>
<th>Participants and willingness</th>
<th>Commodity (%)</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Rice (n=25)</td>
</tr>
<tr>
<td>1</td>
<td>Inexperienced farmers to meet their own needs</td>
<td>25.9</td>
</tr>
<tr>
<td>2</td>
<td>Prospective producer with farmers to meet the needs of VSPGs in the area</td>
<td>29.7</td>
</tr>
<tr>
<td>3</td>
<td>Prospective producer to meet the needs of VSPGs or outsiders and market</td>
<td>33.3</td>
</tr>
<tr>
<td>4</td>
<td>Prospective producer to produce seeds in paddy fields for rainfed or other places (JABALSIM)</td>
<td>11.1</td>
</tr>
</tbody>
</table>

The classification of the progress of the VSPGs could be grouped depending on the ability and sustainability of seed production since 2015 as seen in Fig. 3. The classification ability of 48 units of rice VSPGs could be grouped into 35 units of beginner, 11 units of intermediate and 2 units of advance. Maize VSPGs were grouped into 8 units of beginner, 5 units of intermediate and 2 units of advance among 15 units. Meanwhile for soybean VSPGs there were 18 units of beginner, 6 units of intermediate and 1 unit of advance’.
Based on the partnership plan for seed distribution, the seeds produced by VSPGs were distributed into two different groups, namely for the VSPGs itself or market (AEO, State-owned enterprises, private company). Based on the average rice seed produced by each VSPGs unit, more than 50% of the seeds are utilized by the group itself. However, for the maize and soybean seed the largest portion was utilized by outside the group by AEO, State-owned enterprises, private company (Fig. 4).

List of pre-harvest problems faced: (1) tractor operators were limited to tillage, (2) drought or flooding, (3) pests and weeds, (4) strong winds caused lodging, (5) scarcity of labour from planting until harvest, (6) RSMCC officers were limited, (7) the use of seeds per hectare was more in quantity, (8) plant cultivation techniques have not been mastered. Meanwhile, Post-harvest problems can be listed as: (1) seed processing, (2) storage, (3) marketing, (4) low price, (5) capital to buy produced seeds by the members of VSPGs, (6) payment of seeds was late, (7) low demand caused by free seed distribution by government.
4 Discussions

Modern variety is one of the technological components needed to increase plant productivity [15]. In general, modern variety has better yield potential, and superior agronomic properties. The availability of various MVs can make it easier for farmers to choose varieties to conduct variety rotation, to control biotic stress and optimize yield. The more high-yielding and widely adapted MVs introduced to farmers can increase the adoption of varieties, especially for small-scale farmers to support government programs [16]. The success in disseminating the MVs produced by NRI depend on the participation of non-formal seed producers, both individuals and groups, such as seed producers fostered in the VSPGs program [7], because they provide seed varieties that are not yet popular.

4.1 A nationwide seed production network for in-situ seed provision

In rural agricultural areas that were far from the reach of commercial seeds, farmers were accustomed to use their own seed. Provision of soybean, rice and maize seeds, especially composite maize, was carried out by the farmers themselves, using varieties that are simple in seed processing and superior in consumption characteristics [17]. The ability to provide seeds for specific needs, such as meeting nutritional needs at an affordable price, was an advantage of informal seed provision [18]. Community-based maize seed in Indonesia was more advanced involving NRI as a variety provider directly with local seed producers who were most easily accessed by smallholder farmer with limited arable land [7], but not involved IAIAT yet.

The seed production network could accelerate the availability of in-situ seeds to at least one year after being released. Previous research also stated that VSPGs could accelerate the socialization of varieties [19], multi-location trial of promising lines breeds by the NRI under the IAARD, increase the use of certified seeds to achieve seed self-sufficiency. In line with these findings, other research in Uganda also reported that the availability of information and seed provision will determine the adoption of new varieties [20].

The MVs introduced in the FFS activities were different for each unit. This was due to variations in location, climate, and type of agroecosystem as well as farmer preferences supported by the availability of site-specific adaptive varieties. Therefore, in FFS, there was an FL area that was prepared in addition to display the MVs as well as to study farmer’s preference for the MVs whose seeds will be produced. Previous research stated that the study of consumer preferences was very important in supporting the successful introduction of MVs, which includes study not only of climatic factors, regional ecology, variety attributes, but also farmer gender [21]. The results from another research also revealed that the existence of MVs that match consumer preferences can support the sustainability of the VSPGs in producing seeds [22].

The availability of MVs seeds at the farmer level after release was crucial so that it can accelerate the adoption process [13]. This was in line with the results of research which stated that 63-75% of farmers still use old varieties and unlabelled seeds due to limited access to MVs seeds [23]. Even though the Government has released 133, 86 and 17 MVs for rice, maize, and soybeans, respectively between 2011-2017 with various characters and different adaptability [6]. The provision of in-situ seeds by VSPGs can serve as a trial for market acceptance, as information was indispensable for formal seed producers.
4.2 Capacity building for quality seed production ability

The willingness of VSPGs to produce hybrid maize seeds for their own groups was very realistic, because they found it difficult to compete with private seed producers with capital, technology, and extensive marketing networks [24]. Improvements in crop productivity and disease resistance will increase farmers’ interest in producing these varieties [14]. The willingness of the VSPGs to produce seeds needs to be supported, learning from farmers in Africa who get seeds from informal seed producers [7]. Provision of seeds with seed networks between fields or seasons was an informal seed supply system commonly used for soybeans [25]. Most soybeans were planted only once a year, such as rice fields, those the seeds were prepared during the growing season in other areas.

Post-harvest problems for seed processing and marketing were estimated to cause only a small proportion of VSPGs to be able to do seed business sustainably, even though seed production was feasible [26]. Farmers were also willing to invest their business capital to buy seeds in cash [7], however linking the VSPGs with the market was very important for the sustainability of seed production [27] as also shown by the results of this study. A demand or market that needs to be considered to start a seed business in rural areas, if it was not used alone [25]. Environmental conditioning that allowed the development of a seed supply network was very important to support the change of varieties [28].

5 Conclusion

The efforts have been done up-to now for provision quality seeds of MVs in-situ to stimulate adoption such as: First, the seed production network has been developed in line with the NSS with a reference to CBSS which involving AIAT as a link between the NRI, and the community. VSPGs are given training so that they can produce their own seeds according to consumer preferences. Most of the VSPGs for rice and maize seeds were willing to produce seeds for their own needs or for other farmers in the group. Meanwhile, VSPGs for soybean wish to develop the JABALSIM soybean seed system. Using the network, the MVs seeds released 12 years ago were available soon after being released for adoption. Second, through farmer field schools and support from seed production networks, VSPGs could produce quality seeds, but the sustainability of seed production was hampered by post-harvest handling and marketing problems. Establishing cooperation between VSPGs and seed producers for seed marketing was very much needed for sustainable seed production.

This paper is part of the results of the Food Sovereignty Field Schools That Support Food Self Sufficiency and Integrated in Self Provision of Seed in Villages activity which was funded by IAARD, MOA in the period 2015-2019 fiscal years. We appreciate ICRR, ICERI and ILETRI, and IAIAT in 24 provinces for the collaboration on this work. Appreciation also extended to the Directorate of Food Crops Seed Production MOA, Local Government Office i.e. AEO and RSMCC as well as private sector to whom participated in this network.

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