IMPLEMENTATION RESULTS OF THE NATIONAL RICE PRODUCT DEVELOPMENT PROJECT UP TO THE YEAR 2020 AND ORIENTATION OF PRODUCT RESEARCH AND DEVELOPMENT TO 2030

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ABSTRACT

Rice (*Oryza sativa*) has been regarded as one of the most important food crops that plays an important role in the socio-economic development of Vietnam. Ensuring food security and promoting sustainable rice production and export are two crucial tasks. This report provides an implementation result of the National Rice Product development project up to the year 2020 and anorientation of product research and development to 2030. Particularly, a total of 11 and five new high-grade rice varieties and promising lines have been constructed, respectively. Among them, eight rice varieties, including ĐH12, OM429, BĐR27, GL516, OM375, OM20, OM08, and HD11, were transferred to enterprises and developed in various ecological regions. Furthermore, advanced cultivation practices have been constructed for the Northern provinces, the Red River Delta, the North and South Central regions, and the Mekong River Delta. Certified seeds, registered seeds and basis seeds, together with advanced production models, were developed in many provinces to ensure the production of high-grade rice varieties in Vietnam. Finally, the results of this project offer an opportunity to cooperate with enterprises to promote and replicate the production of newly developed rice varieties and produce rice seeds.

Keywords: *Rice, Vietnam, high-grade variety, National Rice Product, cultivation practices.*

Received: 8 June 2023; revised: 3 August 2023; accepted: 21 September 2023.

1. INTRODUCTION

The development of rice production is one of the most significant successes of Vietnamese agriculture after over 40 years of restoration. Rice cultivation contributes significantly to hunger eradication and poverty alleviation, providing food security and enhancing exports, foreign exchange earnings, and international relations [1].

Despite considerable gains, rice production still has several restrictions. Rice production has grown mostly in terms of breadth (acreage and productivity), whereas rice qualities and post-harvesting technologies are still low and limited, respectively. Furthermore, rice farming consumes significant resources, particularly water, along with fertilizers and pesticides frequently employed to boost yields, leading to resource inputs that can have environmental effects [2]. Despite ongoing advances in rice productivity, Vietnamese rice farmers have low income and considerable risks as compared to other value chain actors [3, 4].

To improve the efficiency of rice production, ensure a stable income for Vietnamese rice farmers, and develop sustainably, the Ministry of Agriculture and Rural Development issued Decision No. 3001/QD-BNN-KHCN dated July 28, 2015 [5] and Decision No. 1261/QD-BNN-KHCN dated April 12, 2016 [6] approving the Project: "Breeding and production of high-grade rice varieties, and development of advanced rice cultivation techniques for high productivity, high quality" under the National Product Development Programme to 2020 (called as National Product Program). Particularly, the Vietnam Academy of Agricultural Sciences is the principal agency for the implementation period 2016-2020, with a total budget of 269,030 billion VND (Vietnam's state budget: 104.25 billion VND and counterpart budget: 164.78 billion VND). The project encompasses eight tasks: one project for rice breeding, three projects for the development of rice production practices for three regions, including the Red River Delta, the Central Coast and the Mekong Delta, and four projects for experimental testing.

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2. OBJECTIVES OF THE NATIONAL RICE PRODUCT

2.1. Overall objectives

The overall objective of this project is to actively engage in the breeding of rice varieties with high quality, high yield, and high commercial value. Also, the development of sustainable rice cultivation practices to improve value-added, lower input costs, minimize greenhouse gas emissions, and boost rice growers' production and profit.

2.2. Detailed goals

- Construction of 4 - 6 new short-duration rice varieties with high yields and good quality.

- Construction of 3 - 5 aromatic rice varieties with short duration, high yield, and good quality.

- Cooperation with enterprises to produce and consume rice, construct typical fields and material-producing areas, ensuring the 2020 plan of achieving 2.0 million hectares per year by using certified seeds (reaching 12 million tons paddy per year) focused in the Red River Delta, the Central Coast, and the Mekong Delta.

- Production of pre-basis rice seeds (at least 35 tons per year), regietered rice seeds (3000 tons per year) and certified rice seeds (130,000 tons per year) for market demand.

- Development of a model for the production of high-grade rice grains and advanced cultivation practices for meeting domestic demand, as well as exporting high-quality rice.

- Construction of sustainable rice cultivation practices (seeds, fertilizers, pesticides and irrigation systems) to decrease prices, reduce greenhouse gas emissions, maintain food safety, and safeguard the environment in the major rice cultivation areas.

- Certification of new rice varieties and development of cultivation practices, and transmission of innovative and sustainable rice farming technologies to firms to increase rice production.

3. MAIN ACCOMPLISHMENTS

3.1. Reports of the project to select and develop rice cultivars with high economic value for the main growing regions

3.1.1. Reports of the rice breeding work

- A total of 11 new rice varieties have been developed from genetic materials. Particularly, six (OM20, OM429, OM375; OM402, OM10636, and BĐR27) and five (HD11, GL516, GL97, VN20, and DH12) rice varieties are generated in the Southern and Northern Vietnam, respectively, with the criteria of yield, quality, resistance to major pests and diseases, and adverse environmental conditions [7, 8, 9, 10, 11, 12]. Among them, five (GL516, ĐH12, OM429, OM402 and OM20) and three (HD11, OM375, and BĐR27) high-quality and aromatic rice varieties, respectively, have been legally approved for commercial release [7, 8, 9, 10, 11, 12].

- A total of five new promising rice lines, including OM08, OM469, OM449, OM476 and BĐR57 are generated to meet market demand. These promising rice lines have been evaluated for further approval.

3.1.2. Reports of the development and production of rice varieties

- ĐH12 rice variety: Since November 2018, Apollo Vietnam Investment and Development Joint Stock Company has had a license for the ĐH12 rice cultivar. The ĐH12 variety shared similar agronomical traits with the KD18 rice variety, such as wide adaptability, decreased susceptibility to pests and diseases, high and reliable yield, and delicious soft grain. The ĐH12 variety was then supplied as the major production variety structure in the Spring season of 2020. The ĐH12 rice variety has been distributed in the growing areas of 30 provinces in the Northern provinces, North Central Coast, and Mekong River Delta as of 2021, with an estimated area of over 80,000 hectares [7, 8].

- OM429 rice variety: By 2021, OM429 rice variety has been planted on approximately 6,000 - 8,000 hectares in the mekong river delta and southeast region of Vietnam. the OM429 variety is highly adaptable, capable of tolerating salinity of 4 - 6‰, and exhibits good rice quality with a high head rice percentage (58 - 64%). This variety exhibits potential expansion of cultivation in the Mekong Delta. the cultivar was transferred to Loc Troi Agricultural Research Institute on June 15, 2021 (Contract no. 08/HD/CGCN-VL).

- BĐR27 rice variety: BĐR27 variety was transferred the exclusive right to exploit and trade the original type and certified to Nong Viet Phat Company Limited on 10 January 2021 under Contract No. 01/ HDBQ. This rice variety has been planted on approximately 1,500 hectares in the South Central

Coast of Vietnam.

- GL516 rice variety: GL516 variety was transferred to Asian Queen Joint Stock Company on 25 December, 2020 under Contract No. 90/HD-CGBQ-VCLT). This variety has been planted on approximately 5,000 hectares in the Northern provinces of Vietnam.

- OM375 rice variety: OM375 variety was transferred to Nha Ho Seed Joint Stock Company on September 16, 2016 under Contract No. 39/2016/HD-CGCN/VL. As of 2021, the OM375 rice variety has been cultivated on around 700 hectares in the Mekong River Delta and Southeast region of Vietnam. This rice variety is highly adaptable and exhibits good resistance to blast disease (point 2), and hardiness (grade 1).

- OM20 rice variety: OM20 variety was transferred to the Nha Ho Research Institute for Cotton and Agricultural Development on May 18, 2018, under Contract No. 18/2018/HD-CGCN/VL. This variety has been cultivated on approximately 700 hectares in the Mekong River Delta and the Southeast region of Vietnam.

- OM08 rice variety: OM08 variety is a fragrant and high-quality cultivar. This rice variety is capable of salinity tolerance of 2 - 3‰. The OM08 rice variety canbe cultivated in three seasons in the Mekong Delta under saline-sodic conditions. The rice quality is comparable to that of the ST25 rice variety.

- HD11 rice variety: HD11 is a fragrant and high-quality rice variety. On July 19, 2020, the variety was certified by the Department of Crop Production under Protection Title No. 28.VN.2020. On October 14, 2019, theHD11 rice variety was transferred to Ha Noi One Member Agricultural Development and Investment Company Limited (Contract No. 65/HD-CGBQ-VCLT) [12]. This variety has been planted on approximately 7,000 hectares in the Northern provinces of Vietnam.

3.2. Reports of the project to establish advanced cultivation practices

3.2.1. Advanced cultivation practices for the Red River Delta

The project has absorbed and integrated concurrently advanced cultivation practices based on summarizing the recent rice farming approaches. These cultivation practices include (i) theapplication of *Trichoderma* spp. to suppress fungal infections and increase the decomposition of rice straw before plowing; (ii) the use of certified seed: pathogens are clearly treated before sowing, as well as the quality of substrates is improved by maintaining pH values and extending seedling shelf life without adding nutrients; (iii) sowing: Transplanting machines are highly recommended; (iv) pesticide application: Using a pressure sprayer with a 20-meter width; (v) fertilizer application: Slow-release fertilizers and fertilizer spraying machines are noticed tobe in use; (vi) irrigation: Water-saving irrigation techniques are applied; and (vii) harvesting: Combined harvesters are used to harvest in the fields.

The application of these advanced cultivation practices could reduce nitrogen by 25-30 kilos N per hectare, phosphorus by 35-40 kilos P_2O_5 per hectare, and potassium by 40-50 kilos K_2O per hectare. Using machinery to sow trays could reduce costs by 2.770 - 3.250 million VND per hectare, while spraying pesticides by machine could save between 2.438 and 2.865 million per hectare. In summary, using the whole package of advanced cultivation practices could significantly reduce production costs by an average of 4.818 - 7.966 million VND per hectare, raising economic efficiency from 17.5 to 36.9%.

According to a survey by the Department of Agriculture and Rural Development and the Center for Agricultural Extension, this advanced technological package has been comprehensively used in six provinces and cities, including Hai Duong, Ha Noi, Bac Ninh, Nam Dinh, Thai Binh, and Ninh Binh, with an entire cultivation area of 6,500 - 7,000 hectares per season. The model's productivity increased by 10-15% due to lower investment expenditures (reduced seed quantity from 10-12 kilos per hectare, fertilizer from 12-45%, pesticide use, and manpower for maintenance). Economic efficiency increased by 25-40% as compared with control.

Under proper conditions, the models are advised to use advanced rice cultivation practices, such as tray plating, transplanting machine, machine sowing, spraying, fertilizer application, and water saving. Fertilize and spray in accordance with the manufacturer's instructions, such as applying slow-release fertilizer, NPK Agrotain fertilizer, and spraying "4 Right".

To sum up, the technical package was acknowledged as a Technical Progress under

Decision No. 321/QD-TT-CLT dated 11/12/2020 [13].

3.2.2. Advanced cultivation practices for South Central regions

The proposed solution for rice cultivation practices in the South Central region of Vietnam has reduced the amount of rice seeds by 50%, from 120 to 60 kilos per hectare, nitrogen fertilizer from 28 - 37 kilos N per hectare (equivalent to 22.5 - 27.8%), spraying times and irrigation water in each season by about 30% and production costs by 2.851 - 3.882 million VND per hectare (equivalent to 10.13 - 12.00%). Yield increased from 479 - 546 kilos per hectare (equivalent to 6.9 - 8.0%) as compared to the control. The average expected profit is approximately 22.960 - 23.219 million VND per hectare, which is greater than the control of 6.482 to 6.495 million VND per hectare (equivalent to 38.8 - 39.3%). Furthermore, these rice cultivation practices are being used to lower CH_4 and N_2O emissions from 20.77 to 23.55 kilos per hectare per season and from 0.99 to 1.17 kilos per hectare per season, while total CO_2 emissions dropped from 814.3 to 937.4 kilos per hectare per season when compared to traditional farming.

Similarly, the proposed solution of rice cultivation practices for the North Central region in Vietnam has reduced the amount of rice seeds by 5 kilos per hectare, nitrogen fertilizer by 14 kilos N per hectare (equivalent to 12.7%), irrigation water in each season by over 30% and production costs by 1.8 - 2.6 million VND per hectare. Yield increased from 719 - 797 kilos per hectare (equivalent to 11.6 - 12.14%) as compared to the control. The average expected profit ranged between 29.635 and 30.225 million VND per hectare, which was greater than the control of 8.203 to 8.652 million VND per hectare (equivalent to 36.43 - 41.23%). The advanced technical package aids in lowering CH_4 and N_2O emissions from 98.22 to 117.09 kilos per hectare per season and from 1.08 to 3.04 kilos per hectare per season, while total CO_2 emissions are lowered from 2,776 - 3,834 kilos per hectare per season as compared to traditional farming.

The Department of Agriculture and Rural Development and the Center for Agricultural Extension did a survey that showed, that advanced technological package has been comprehensively used in four provinces, including Thanh Hoa, Nghe An, Quang Nam and Binh Dinh, with the entire cultivation area of approximately 2,200 hectares per season. Meanwhile, the proposed solution to rice cultivation practices for the South Central region of Vietnam has reduced the amount of rice seeds by 40 - 50%, irrigation water in each season by 30%, and pesticides by 1 - 2 times per season. Yield increased by 8%, while economic efficiency increased by 20% as compared with control.

To sum up, the technical package was acknowledged as a Technical Progressunder Decision No. 23/QD-TT-VPPN dated 25/01/2021 [14].

3.2.3. Advanced cultivation practices for the Mekong River Delta

Apackage of advanced rice farming practices has been performed in four sub-regions in the Mekong River Delta, including the three-season alluvial ecological sub-region (Cho Moi, An Giang), the two-season alluvial ecological sub-region (Thoi Lai, Can Tho), the alkaline soil ecological sub-region (Long My, Hau Giang), and the saline soil ecological sub-region (Tran De, Soc Trang). Economic efficiency of this package increased by 25-40% as compared with traditional farming. The technological packages aim to restrict greenhouse gas emissions (CH_4 and N_2O) and the influence on soil nutrients in each ecological region, in addition to lowering input prices. After one week of rice harvest, the rates of CH_4 and N_2O emissions in all of the advanced rice crops in the four eco-regions were lower than the average values in the old-fashioned fields for the period. The new model reduces CH_4 gas emissions by 66.6 - 93.9% and N_2O gas emissions by 15.9 - 80.6%; total greenhouse gas emissions converted to CO_2 are lowered by 8 - 9% compared to farmers' farming methods.

Particularly, according to a survey by the Department of Agriculture and Rural Development and the Center for Agricultural Extension, this advanced technological package has been comprehensively used in four provinces, including Can Tho, An Giang, Soc Trang, and Hau Giang, with an entire cultivation area of approximately 3000 hectares per season. Economic efficiency of this package increased by 25-41% as compared with traditional farming. The proposed solution of rice cultivation practices for these regions has reduced

the amount of rice seeds by 80 - 120 kilos per hectare, nitrogen fertilizer by 20 - 40 kilos N per hectare (equivalent to 18 - 45%), phosphorus fertilizer by 20%, potassium fertilizer by 23%, irrigation water in each season by 3 - 4 times, and pesticide use by 2 - 4 times.

Overall, under proper conditions, the models are advised to use advanced rice cultivation practices. It could reduce the certified rice seeds by 80 - 120 kilos per hectare per season (equivalent to 30 - 50%), water use by 3 - 4 times per hectare per season (equivalent to 30%), fertilizer and pesticide use by 20 - 30%. Cutting between the rice stalks at harvest time reduces loss by 10-14% and boosts overall rice yield by 5-12% compared to conventional cultivation practices in all regions.

The technical package was acknowledged as a Technical Progress Under Decision No. 24/QĐ-TT-VPPN dated 25/01/2021 [15].

3.3. Reports of the project to produce high-grade rice varieties for production

3.3.1. Japonica rice production in Northern provinces in Vietnam

The initiative produced pre-basis *Japonica* rice varieties in Ha Noi, Ha Giang, and Phu Tho across an area of 8.5 hectares, yielding 26.8 tons of pre-basis rice seeds (reaching 89% in volume) that met the QCVN 01-54: 2011/BNNPTNT standard [16]. For the basis rice variety, production was arranged on a 60-hectare scale in the provinces and cities, including Ha Noi, Thanh Hoa, Yen Bai, Ha Giang, and Phu Tho, with a total production of 321.1 tons (reaching 53.5% in volume). The majority of the basis seed batches were used by businesses as a source of certified seed production to provide the locality. During the Spring season 2020, the project continued to deploy seed production models (joint enterprises) and commercial *Japonica* rice production models in Ha Giang, Vinh Phuc and Thanh Hoa provinces.

3.3.2. Rice production in the Northern provinces and South Central regions in Vietnam

The project has completed the industrial-scale validation breeding procedure for rice varieties BT09, LTH31, QP5, and Dong A1 (varieties that have been formally acknowledged by the task's contents). The project is expected to produce 57.35 tons of pre-basis rice seeds and more than 2,611 tons of basis rice seeds by the end of 2020, offering all cultivation areas of certified seeds on 20,000 hectares in the Northern provinces and South Central Coast in Vietnam.

3.3.3. Rice production of the North Central regions in Vietnam

This project has produced 47 tons of pre-basis rice seeds that were standardized by the Vietnamese quality standards (QCVN 01-54: 2011/BNNPTNT) [16], as well as 2,500 tons of basis rice seeds and 50,000 tons of certified seed for cultivation in the North Central region in Vietnam. By the end of 2020, the project will have completed 100% of the ordered seed production volume at all stages.

Furthermore, the project is implementing the supply and installation of machinery and equipment to meet the demands of seed processing, including 01 industrial-scale seed processing line with a capacity of 2.5 tons per hour, 01 seed testing and inspection laboratory to meet current regulations and 01 cooling system for preserving rice varieties. The contents of the construction and installation were finished and placed into operation in the fourth quarter of 2020, satisfying 100% of the anticipated content and volume.

3.3.4. Rice production in the Mekong Delta in Vietnam

The seed production and intensive farming process for rice types suitable for the region, such as OM18, OM9582, OM22, OM9921, and OM20 rice varieties, has been finished. Two fragrant rice cultivars, OM18 and OM9921, achieve the highest average yield in all three ecological sub-regions in the Mekong Delta. Furthermore, the project determined the best fertilizer formulary, harvesting times for each rice variety, as well as the processing quality of each rice type. The initiative organized the production of pre-basis rice seeds over a 20-hectare area, yielding more than 70 tons of seeds that met QCVN 01-54: 2011 criteria [16]. In terms of basis rice variety production, the project has collaborated with a number of units and businesses to organize 520 hectares of joint production models of basis rice varieties, with a total basis seed output of more than 2,800 tons.

3.4. Construction of anadvanced production model for high-grade rice varietiy cultivation

3.4.1. Construction of anadvanced production model for high-grade rice variety cultivation in the Red River Delta

The small-area testing showed that using slow-release fertilizer saves 22 - 50% of total fertilizer while still producing an 8 - 13% higher yield than the control in the Red River Delta. The use of mechanization can result in an average profit of 25 - 30 million VND per hectare, which is greater than the traditional conventional farming profit of 5 - 8 million VND per hectare (equivalent to 27 - 46%). Furthermore, when compared to traditional farming, the technology package reduces total emissions by 8.8 - 15.1%.

On that premise, it has been implemented on a broad scale with the collaboration of firms (Hung Cuc Limited Liability Company, Hong Quang Seed Joint Stock Company, Vietnam Seed Joint Stock Company, and Seed Joint Stock Company belonging to Field Crops Research Institute, with a total area of 160 ha in four ecological sub-regions in the Red River Delta. The economic efficiency of the models' rice production outputs exceeds 20.5 - 30.5% (Spring season) and 22 - 30% (Summer season) when compared to the control. In the near future, a technical package will be signed and transferred to these enterprises in order to implement commodity rice production organization on a wide scale, rapidly increasing the rice production area using innovative farming techniques. Farmers in the Red River Delta will benefit from this.

3.4.2. Construction of advanced production model for high-grade rice varieties cultivation in North Central regions

The concept was tested on a 40-hectare scale in Nghe An and Thanh Hoa provinces, and it lowered production expenses from 0.99 to 2.74 million VND per hectare (equivalent to 3.18 - 8.74%), raised output from 757-866 kilos per hectare (equivalent to 10.18-12.3%), and boosted profit from 6.78 - 9.25 million VND per hectare (equivalent to 28.4 - 30.2%). The amount of irrigation water has been decreased by 30% due to the use of the "alternating dry-wet" watering method; the model is used in conjunction with integrated pest control, thus the number of times pesticides have been sprayed has been reduced by 30%. In the case of pesticide use, the "4 Right" principle was applied to minimizie environmental contamination and toxicity to farmers. In addition, the entire production area has been used with combine harvesters in harvesting and drying, so the loss is reduced by less than 5%.

3.4.3. Construction of advanced production model for high-grade rice varieties cultivation in South Central regions

The concept was tested on a 40-hectare scale in Binh Dinh and Quang Nam provinces, and it lowered production expenses from 2.18 to 3.25 million VND per hectare (equivalent to 10.84 - 14.63%). The productivity was from 8.0 to 8.7 tons per hectare, slightly higher than the control. It has been boosted profit from 6.781 - 9.25 million VND per hectare (equivalent to 28.39 - 30.22%). The amount of irrigation water has been decreased by 30% due to the use of the "alternating dry-wet" watering method; the model is used in conjunction with integrated pest control, thus the number of times pesticides have been sprayed has been reduced by 30%. In the case of pesticide use, the "4 Right" principle was applied to minimizie environmental contamination and toxicity to farmers. Additionally, the entire production region has used combine harvesters to gather and dry seeds, reducing loss to less than 5%. The process's application area has been enlarged to over 1200 hectares in the South Central region (for the Northern and Southern sub-regions) by 2020.

3.4.4. Construction of advanced production model for high-grade rice varieties cultivation in Mekong Delta

The concept was tested in the Mekong Delta reveals that the amount of seeds has been lowered from 170-200 kg (control) to 80 - 120 kg of seeds (advanced model). It reduced the amount of fertilizer by 15 - 20%, the amount of pesticide uses by 900,000 to 1,850,000 VND per hectare, and water uses by 1-3 times per season as compared to the conventional methods. Furthermore, our results demonstrated that the amount of CH_4 and N_2O were greatly variable. The productivity ranged from 5.17 - 6.45 tons per hectare, whereas that in the control ranged from 5.06 - 5.97 tons per hectare, resulting in a better profit for the advanced model. In comparison to the conventional cultivation practices, the average profit increased by 1.0 - 1.6 million VND per hectare.

3.5. Cooperation with enterprises

3.5.1. Cooperation with enterprises to promote and replicate the manufacturing of newly developed rice varieties

The project's units have actively collaborated with firms operating in the field of rice seeds and agricultural materials in regions across the country since the project's inception. The strategy is that research units collaborate with enterprises beginning with the identification and selection of elite rice lines and continuing with the process of pure selection, testing, assessment, and the development of pilot production models.

Next, businesses can engage in developing promising rice varieties that meet their needs and business orientations in specific regions, so tying their interests to the development and expansion of varieties. When these businesses are permitted to begin production, they will be granted first priority in negotiating the transfer of seed use rights. In fact, up until the time of reporting, whole seven new rice varieties that had been approved for trial production/official release had worked closely with firms. Through this collaboration, new rice varieties are guaranteed to be promoted and introduced promptly and extensively through the seed distribution system of firms, making a vital contribution to achieving the criteria for area expansion.

3.5.2. Cooperation with enterprises to produce rice seeds

Production of Japonica rice varieties for the Northern provinces in Vietnam: Japonica rice varieties, such as J02, J01 and VAAS16 were cultivated by concentrated commodity chains in the Northern mountainous regions, Red River Delta, and North Central regions in Vietnam since the Spring 2020 season. The chairing unit has coordinated with enterprises such as Vietnam Seed Group Joint Stock Company and Vietnam Hi-Tech Company to develop large-scale models of japonica rice production on a size of 300-350 hectares for the Spring 2020 season.The models have been implemented from the stage of selecting a location, organizing the production material area, contracting with project participants, and training farmers on the technical process of intensive japonica rice cultivation with quality and efficiency, thereby ensuring japonica rice production and processing to meet export and domestic consumption needs.

Production of Indica rice varieties for the North and South Central provinces: A Indica rice varieties, including BT09, LTH31, QP5 and Dong A1 were cultivated at the industrial scale. The large sample field linkage model yields commercial rice at 66.7% area and 97.5% production. The model of linking large sample fields achieved 100% area and 111.9% yield for fragrant rice varieties.

Production of Indica rice varieties for the North Central region: Nghe An Agricultural Materials Corporation has finished the construction, installation, and testing of equipment as well as cold storage. In the Company's headquarters and the 6,000 m^2 rice milling and processing warehouse in Nghi Long Factory, Dong Nam Industrial Park, Nghi Loc district, Nghe An province, rice seeds are tested, processed, and preserved. Furthermore, the lead unit has implemented the development of model field linkage models based on the value chain at various sites in the North Central region, including the model of linking production of high-grade NA6 rice varieties with high quality standards. A 20-hectare scale in the spring crop of 2019 in Thach Dai commune, Thach Ha district, Ha Tinh province, a 450-hectare commercial rice production model in Thanh Hoa (200 hectares), Nghe An (200 hectares), and Ha Tinh provinces (50 hectares). In the models, the average yield was 6.5 - 7.0 tons per hectare in the Spring season and 5.3 - 5.6 tons per hectare in the Summer season. Spring season 2020 has deployed 5 models of large sample field linkages producing high-grade seeds (total area of 100 hectares) and 8 models of linking large sample fields producing commercial rice (total area of 400 hectares) in the provinces of the North Central region.

Production of *Indica* rice varieties in Mekong Delta: In the Mekong Delta provinces, the project is collaborating with the Seed Center, agricultural cooperatives, and the Department of Agriculture to deploy large sample fields to produce fragrant rice on a scale of 150 hectares and rice on a scale of 300 ha during the Spring season 2019-2020. The aromatic rice variety OM18 yielded 6.8 tons per hectare, whereas the high-quality rice variety OM9582 yielded 7.2 tons per hectare. In the 2019-2020 Spring season, the project was implemented on a scale of 150 hectares for the fragrant rice model and 300

hectares for the high-quality rice model in the next seasons in 2020. The models have been deployed from the stage of selecting a place, organizing the production material area, contracting with farmers participating in the project, and training those farmers on the technical process of commodity rice intensification with high efficiency and excellent quality rice varieties, assuring the production and processing of rice output to satisfy the requirements of export and home consumption.

4. SHORTCOMINGS, GAPS IN SCIENTIFIC AND TECHNOLOGICAL RESEARCH AND LESSONS LEARNED

Aside from the aforementioned accomplishments, Vietnam's rice business still faces numerous challenges. Export prices and competitiveness remain low, failing to fulfill the diversified needs of domestic and international markets; production and business efficiency remain poor, failing to match potential and advantages. Farmers' incomes are low and inconsistent, and there is no harmonization of interests across participants in the value chain. Rice production development is not sustainable; there are still many hazards in production and business, such as polluting the soil and water environment, damaging biodiversity, and being insensitive to the consequences of climate change.

4.1. Issues during the production stage

- Smallholder farmers' production scale is modest, and farmer association organizations (cooperatives) and farmer representation organizations have not been interested in development.

- Production relies on experience, a lack of scientific and technological information, and a lack of a market; young workers are leaving for other occupations; the level of intensive farming varies between areas, regions, and households within the same production area.

- Production is not in accordance with market demands; various types are grown in the same field, resulting in low and inconsistent quality of exported rice batches. The export rice variety set is still primarily aimed at markets that are simple to compute and sell at low prices. There are no fragrant, high-quality rice cultivars comparable to Pakistan's and India's Khao Dawk Mali 105 (Hom Mali) or Basmati. The majority of the known variants are resistant to brown planthoppers, blight, and rice blast.

- Input material quality (fertilizers, pesticides, seeds) has not been adequately managed; excessive use of fertilizers, pesticides, and seeds raises costs and pollutes the environment. The incidence of using certified seeds in the Mekong Delta is low, at roughly 15%, and the volume of seeds utilized is excessive (150-180 kilos per hectare).

- The use of good agricultural practices in production (IPM, 3 decrease -3 rise, 1 right - 5 decrease, VietGAP...) is still restricted, with inadequate attention paid to food safety and environmental protection.

- Rice monoculture, failure to pay attention to crop rotation, altering crop structure on rice land in order to improve efficiency, income, minimize pest and disease pressure, and lessen strain on rice consumption and export.

4.2. Issues during the post-harvesting process

- A lack of drying systems, particularly in the Mekong Delta's summer season, is generating losses and lowering the quality of exported rice.

- Buying rice is primarily dominated by private traders; thus, there is no guarantee of quality and no creation of a brand.

- Stored as brown rice before whitewashing and polishing for export; therefore, rice quality degrades quickly.

- In-depth processing, diversification of rice and rice-based products is restricted; no attention is paid to the utilization of by-products (rice husk, bran, rice straw, etc.) to boost added value and production efficiency.

4.3. Rice sector infrastructure and logistics are still restricted

The transportation and irrigation infrastructure have not been finished and do not meet production standards. The transportation system connecting manufacturing areas to the points of consumption and export is inadequate. Information systems and market ties are extremely restricted.

4.4. The shaky links between actors in production, purchasing, processing, and consuming

- Farmers and private traders (who collect over 90% of rice in the Mekong Delta), rice processing companies, and exporting enterprises are all part of the rice value chain. Unaffiliated rice, efficiently

assisting one another for mutual advantage.

- Because most exporters acquire rice from private traders who are not affiliated with farmers to create vast fields and raw material areas, the quality of exported rice is low because firms collect from a variety of sources.

4.5. Policies have not met production and business requirements

- Small and vulnerable farmers; cooperatives play a limited role; enterprises mostly participate in the latter stage of the value chain, are unattached, and pay little regard to farmer issues.

- The Food Association does not yet represent all production and commercial actors along the rice value chain.

- Policy on land acquisition, credit, association support, and enterprise investment in agriculture is still limited and insufficient.

5. PRODUCT RESEARCH AND DEVELOPMENT ORIENTATION TO 2023

In order for the rice industry to continue to promote its existing advantages and maintain a strategic position in Vietnam's agricultural sector, it must continue to promote rice exports in the direction of raising prices, in addition to meeting the domestic market. Rice research, selection, and production not only assure food security in terms of quantity, but also of food safety and nutritional quality, contribute to community health improvement, and fits demands and tastes. Increasing consumer demand, environmental preservation, and climate change adaptation. To achieve the aforementioned objectives, the following specific solutions are available:

5.1. Rice breeding work

- Continuing to research and select high-quality, fragrant, high-priced rice varieties that are competitive in both export and domestic markets, are resistant to major pests and diseases, and prefer short-growth or high-quality aromatic mid-day lines.

- The Mekong Delta region is primarily focused on the export market, while also paying close attention to the domestic market; high-quality rice varieties (white rice, long grain, lightly fragrant or not fragrant) account for approximately 50% of the cultivated area; fragrant rice varieties account for approximately 25%; glutinous varieties, local specialties account for approximately 15%; and average-quality varieties account for approximately 10%.

- The Red River Delta and the remaining cultivation regions are mostly aimed at the domestic market; rice varieties with high selling prices and good quality rice are primarily used. They mostly focused on the high-quality rice varieties, such as glutinous rice varieties and japonica rice varieties, account for approximately 60% of the cultivation area, while high-yielding types account for approximately 40%.

5.2. Application of sustainable cultivation practices in rice production regions

- Establishment of policies of area planning to construct a large rice production area with synchronous infrastructure for commercial rice production.

- Upgrading, improving, and creating irrigation and electricity systems in the field to replace oil-based pumps.

- Using certified seeds (level 1 or level 2), the rate of use of certified seeds in Vietnam will exceed 95% by 2030.

- Prioritizing the use of organic fertilizers, rice-tailored synthetic NPK fertilizers; fertilize based on soil nutrition and rice demands; minimize fertilizer consumption by at least 30% over current levels.

- Implementing integrated pest management on the entire rice cultivation area; organize full-time plant protection services at the facility; rationally use herbicides, only use pesticides when necessary, and must adhere to the "4 rights" principles; reduce pesticide use by at least 30% compared to current levels.

5.3. Post-harvesting management

- Using high-tech combined harvesters to harvest rice in major cultivation areas, with a residual harvest of less than 1.5%.

- Converting the rice drying system from 2-step drying to 1-step drying using fluidized bed drying and tower drying. Drying fresh rice to the standard moisture content of 14.0 -14.5% in order to transition from preserving dry rice grains to dry rice seeds.

- Screening of the warehouse system (4 million tons capacity), balancing the demand for storing rice in specialized cultivation regions in order to construct and upgrade the rice storage system with drying, cleaning, and automation systems.

- Assistance with land, funding, and market access for cooperatives and allied businesses in important specialized farming areas to construct dry rice storage facilities.

- Assisting businesses in purchasing advanced processing technology, such as deep processing. Creating a direct trading platform for business-to-business transactions to exchange processing technology.

5.4. Prevent the effects of climate changes

Report and constantly update climate change scenarios for rice production in Vietnam; design synchronous response solutions for each scenario, focusing on the following solution groups:

- Develop and implement technical packages to adapt to climate change: alter the season, adjust the cultivation regions, develop and implement resistant rice varieties, and implement appropriate cultivation practices, like rotation, multi-cropping and intercropping to reduce risks and capitalize on natural advantages.

- Research and implement strategies to reduce greenhouse emissions and mitigate the effects of climate change: rationally manage water use to save water for rice production, reduce agricultural material consumption.

- Implement production planning and shift population clusters in response to climate change scenarios.

- Invest in constructing a protection forest system and building infrastructure, including irrigation systems and roads, to adjust to climate change.

5.5. Risk management

- Creating an information system for proactive warning, weather forecasting, natural disaster prevention and control, and epidemic prevention and control.

- Implement a rice agricultural production insurance program (support and encourage farmers to purchase insurance, and encourage insurance companies to engage in the market).

- Financial, technical, and in-kind assistance to rice farmers in the event of catastrophic natural catastrophes to restore production and stabilize livelihoods.

- Investigation of rice varieties that are resistant to major pests and diseases, and adverse environmental conditions. Application of eco-friendly rice farming to minimize the impacts of pests, diseases and climate changes. Also, to establish a dependable, pest-resistant, disease-resistant, and disaster-resistant seed supply system in each production region.

- Implement policies to encourage the use of integrated pest management, sustainable farming to provide a stable ecological environment, and the prevention of pesticide resistance.

REFERENCES

1. Tran Dang Khanh, Vu Xuan Duong, Phi Cong Nguyen, Tran Dang Xuan, Nguyen Thanh Trung, Khuat Huu Trung, Dong Huy Gioi, Nguyen Huy Hoang, Hoang Dung Tran, Do Minh Trung, Bui Thi Thu Huong (2021). Rice breeding in Vietnam: Retrospects, challenges and prospects. Agriculture. 11(5): 397.

2. Jianxin Shi, Gynheung An, Andreas P. M. Weber & Dabing Zhang (2023). Prospects for rice in 2050. Plant, Cell & Environment. 46(4): 1037-1045.

3. N. C. Dinh, T. Mizunoya, V. H. Ha, P. X. Hung, N. Q. Tan & L. T. An Factors influencing farmer intentions to scale up organic rice farming: preliminary findings from the context of agricultural production in Central Vietnam. Asia-Pac J Reg Sci. 2023 Mar 9:1-26. doi: 10.1007/s41685-023-00279-6.

4. L. Chu, H. T. Nguyen, T. Kompas, K. Dang & T. Bui (2021). Rice land protection in a transitional economy: The case of Vietnam. Heliyon. 7(4): e06754.

5. Ministry of Agriculture and Rural Development of Vietnam (2015). Decision No. 3001/QD-BNN-KHCN dated July 28, 2015, on approving the objectives, content, organization and individual in charge, funding and duration to implement national science and technology tasks of the Project "Breeding and production of high-grade rice varieties, and development of advanced rice cultivation techniques for high productivity, high quality".

6. Ministry of Agriculture and Rural Development of Vietnam (2016). Decision No. 1261/QD-BNN-KHCN dated April 12, 2016, on approving the objectives, content, organization and individual in charge, funding and duration to implement national science and technology tasks of the Project "Breeding and production of high-grade

rice varieties, and development of advanced rice cultivation techniques for high productivity, high quality".

7. Ta Hong Linh, Tran Van Quang, Trinh Khac Quang, Le Quoc Thanh, Chu Duc Ha, Bui Quang Dang, Tran Duc Trung (2019). Evaluation of the fertilizer and planting density on the growth and development of the inbred rice variety DH12. *Vietnam Journal of Agriculture and Rural Development*, 13: 19 - 25.

8. Trinh Khac Quang, Tran Van Quang, Le Quoc Thanh, Bui Quang Dang, Chu Duc Ha, Tran Duc Trung, Ta Hong Linh (2019). Testing of inbred rice variety DH12 in Northern provinces of Vietnam. *Journal of Vietnam Agricultural Science and Technology*, 8(105): 50 - 54.

9. Ta Hong Linh, Trinh Khac Quang, Nguyen Trong Khanh, Chu Duc Ha, Tran Duc Trung, Bui Quang Dang (2019). Evaluation of the agronomical traits of the romising rice lines towards the national rice production. *Journal of Science and Technology - Thai Nguyen University*, 207(14): 161 - 167.

10. Ta Hong Linh, Trinh Khac Quang, Tran Van Quang, Chu Duc Ha, Tran Duc Trung, Bui Quang Dang (2019). Evaluation of the promising rice (*Oryza sativa*) lines for the national rice production strategy. *Vietnam Journal of Science and Technology*, 61(11): 70 - 73.

11. Ta Hong Linh, Trinh Khac Quang, Nguyen Trong Khanh, Pham Van Tinh, Nguyen Anh Dung, Le Thu Hang, Chu Duc Ha, Tran Duc Trung (202[0). Ecological testing and completion of cultivation procedures for inbred rice variety Gia Loc 37 in the Northern provinces. *Journal of Vietnam Agricultural Science and Technology*, 1(110): 57 - 61.

12. Ta Hong Linh, Duong Xuan Thu, Chu Duc Ha, Trinh Khac Quang, Tran Duc Trung (2020). Results of testing and construction of cultivation for the inbred rice variety HD11 towards the development of the national rice production. *Vietnam Journal of Science and Technology*, 62(9): 32 - 35.

13. Ministry of Agriculture and Rural Development of Vietnam (2020). Decision No. 321/QD-TT-CLT dated December 11, 2020. Technical Progress in Crop Production.

14. Ministry of Agriculture and Rural Development of Vietnam (2021). Decision No. 23/QD-TT-VPPN dated January 25, 2021. Technical Progress in Crop Production.

15. Ministry of Agriculture and Rural Development of Vietnam (2021). Decision No. 24/QD-TT-VPPN dated January 25, 2021. Technical Progress in Crop Production.

16. Ministry of Agriculture and Rural Development of Vietnam (2011). National Technical Regulation on Seed Quality of Rice - QCVN 01-54: 2011/BNNPTNT.