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Political Economy of the Wheat Sector in Uzbekistan

Seed Systems, Varietal Adoption, and Impacts

Editors:

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Preface

In Uzbekistan, wheat not only has high economic importance, but it also symbolizes independence, sovereignty, food security, and self-reliance. After independence from the Former Soviet Union (FSU) in 1991, the country started to make concerted efforts towards food self-sufficiency. Consequently, the wheat area increased significantly from about 0.63 million hectares in 1991 to about 1.31 million hectares in 2019 (35% of total arable land) – making wheat the second most important crop after cotton. Likewise, total annual wheat production has increased significantly since 1991, reaching 6.09 million tons in 2019, with 80% grown on relatively large, irrigated farms. The increase in production is mainly due to area expansion and yield gains from using new, irrigation, improved and productive, varieties, and intensive crop-management practices. In 2017-2018, domestic wheat production met more than 70% of domestic food and feed demand in the country showing the country's progress in its effort to become self-sufficient in wheat.

The state of the wheat sector in Uzbekistan hinges on the Government policies of "independence in cereals" introduced in 1993, and "self-sufficiency in wheat" introduced in 1994, which was directed at increasing domestic wheat production via three measures (Lombardozzi and Djanibekov, 2020), namely: 1) government wheat production targets through a quota system; 2) provision of subsidized inputs (water, fertilizers, diesel, machinery services, and credit) to farmers; and 3) a bread subsidy program to limit wheat price volatility by controlling the distribution of domestically produced wheat and flour. Despite several Government reforms since independence, certain features of the centrally planned command economy continue. For example, wheat production, processing, and marketing remain rooted in the FSU practices and are centrally governed. Moreover, a Government procurement system still operates for wheat and cotton crops, where farmers have to sell at least 50% of their produce to the Government through a quota system. In return, farmers receive credits for seeds, fertilizers, and other inputs, which they repay when selling their harvest to the Government at a fixed price. This system allows farmers to sell any surplus produce (over the 50% Government quota) in the market, which often fetches them up to double the price they receive from the Government. This is believed to provide an incentive for farmers to use improved technologies that boost the productivity of their farmland.

The history of wheat breeding in Uzbekistan dates back to 1909, when under the FSU, the Department of Dryland Farming of the Turkestan Experimental Station collected wheat landraces in the Turkestan territory. The Turkestan Experimental Station was governed by the former Central Asian Branch of All-Union Academy of Agricultural Sciences of the Soviet Union – a network of research institutes across Central Asian Republics including Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan. This was followed by the establishment of the Grain Research Station (1913-1956), which was later (1956-1992) renamed as Research Institute of Rainfed Farming. On the other hand, the major thrust in national seed system development, and particularly the wheat seed sector, started after independence in 1991. Several reforms and reorganizations led to the establishment of the Research Institute for Cereal and Legume Crops (1992), the State Variety Testing Commission (1991), and the State Seed Quality Control and Certification Center (1995). Together, these laid the foundation for a national seed system. This was followed by a succession of presidential decrees, resolutions, and enactments of laws including the basic national Seed Law #267-I (August 29, 1996) which saw its latest amendment (law #521) in February 16, 2019 and the Law on Breeding Achievements #395-II (29 August 2002).

Political Economy of the Wheat Sector in Uzbekistan: Seed Systems, Varietal Adoption, and Impacts, is the third book in a series where the preceding two focused on Morocco and Turkey. The series has been possible thanks to the financial support from the CGIAR Research Program on Wheat (CRP-Wheat). This book compiles several studies conducted on different aspects of the wheat sector in Uzbekistan. It focuses mainly on the seed value chain and covers the entire continuum from variety development– to seed production, and marketing – to varietal adoption and impacts.

The book is organized as follows:

- Chapter 1 highlights the historical developments of the wheat grain and seed sector, including policy and regulatory frameworks.
- Chapter 2 presents the development of agricultural research institutes and hence, the generation of improved wheat varieties.
- Chapter 3 focuses on varietal release and protection.
- Chapter 4 presents a description of the procedures and status of production and commercialization of early generation (super elite and elite), and certified seed.
- Chapter 5 elaborates on seed quality assurance and certification.
- Chapter 6 describes the status and determinants of adoption of improved wheat varieties and provides estimates of their impacts as well as the annual quantities of wheat seed use.
- Chapter 7 provides a bird's-eye view of the whole wheat sector in Uzbekistan by synthesizing and establishing links between the achievements, limitations, challenges and opportunities documented in each of the preceding 6 chapters and makes recommendations for the way forward.

This comprehensive book, the first of its kind in the country, brings most of the available published and unpublished secondary data and information related to the wheat sector in Uzbekistan. It complements the secondary data with rich primary data from two waves of nationally representative surveys carried in 2013 and 2017. The analysis carried in the book heavily draw on the rich combined wealth of experiences of the authors and editors. We expect this book to be the "go to" reference material for wheat in Uzbekistan and a great resource for several years to come. We hope that the guidance and recommendations contained in this book will be useful for policymakers, researchers, farmers, private and public seed companies, and development partners in their effort to overcome major challenges, exploit available opportunities, and create a conducive environment for faster and more sustainable development of the wheat sector in Uzbekistan.

Editors

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Acronyms

CAC	Central Asia and the Caucasus
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Center
CSPC	Cotton and Cereal Seed Production Center
DCACSP	Department for Control of Agricultural Crop Seed Production (of SIAC)
DUS	Distinctness, Uniformity and Stability
FAO	Food and Agriculture Organization of the United Nations
FSU	Former Soviet Union
GDP	Gross Domestic Product
GOST	Gosudarstvennye Standarty (State Standards)
GoU	Government of Uzbekistan
IAC-DCAC	Inspectorate of Agro-industrial Complex, Department for Control of Agricultural Crop Seed Production (ex. State Seed Certification and Quality Control Center = SSCQCC)
ICARDA	International Centre Agricultural Research in the Dry Areas
IPR	Intellectual property rights
ISF	International Seed Federation
ISTA	International Seed Testing Association
JICA	Japanese International Cooperation Agency
MoA	Ministry of Agriculture (ex. Ministry of Agriculture and Water Resources – MoAWR)
MoF	Ministry of Finance
MoJ	Ministry of Justice
NARS	National Agricultural Research System
NCS	National Certification System
NPPO	National Plant Protection Organization
O‘zDSt	Uzbekistan State Standards
OECD	Organization for Economic Cooperation and Development
PD	Presidential Decree
PFU	Project Facilitation Unit
PVP	Plant Variety Protection
RIPI	Research Institute of Plant Industry
RIRF	Research Instiute of Rainfed Farming
RST	Republican Standards for Testing
SDC	Seed Development Center
SIAC	State Inspectorate for Agro-industrial Complex
SSCQCC	State Seed Certification and Seed Quality Control Center
SIPA	State Intellectual Property Agency
SRIA	South Research Institute of Agriculture
SVTC	State Variety Testing Commission
UPOV	International Union for Protection of New Varieties of Plants
USD	United States Dollar
Uzdonmakhsulot	Uzbek Grain Production Joint Stock Company
RICLC	Research Institute for Cereal and Legume Crops
UZS	Uzbek Soums
VCU	Value for Cultivation and Use
WIPO	World Intellectual Property Organization

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CHAPTER I

The Wheat Sector in Uzbekistan

Aziz Nurbekov, Zewdie Bishaw, Bakhodir Kuziyev, Yigezu Atnafe Yigezu, and Abdoul Aziz Niane

1.1 Introduction

Agriculture plays an important role in the economy of Uzbekistan contributing 16% to GDP and 44% to employment. Uzbekistan has a land area of 44.8 million ha, of which about 4.5 million ha is arable, and 4 million ha is irrigated. Main cultivated crops are cotton, wheat, barley, rice, maize, potatoes, and horticultural crops (vegetables and fruits). The population of Uzbekistan was estimated at 34 million in 2019 and continues to grow at a rate of 1.67% per year (WB, 2019). Currently, an estimated 18 million people live in rural areas, most of which draw their livelihoods from agriculture.

During the Former Soviet Union (FSU) era, Uzbekistan was a major producer of cotton, vegetables, and fruits. About 70% of irrigated land was devoted to cotton production, while fodder crops (alfalfa, rye, barley, and maize) were grown in rotation with cotton and supported limited livestock production. Wheat, one of the key food security crops, was mostly imported from other regions of the FSU, with local production meeting only 20% of domestic demand.

After its independence in 1991, Uzbekistan's access to strategic food imports became less secure due to the abolition of the centrally coordinated commodity supply and subsidy systems between Russia and its Soviet Socialist Republics. Subsequent structural adjustments by the former Soviet republics made the contracting system less reliable and reduced regional trade. As a landlocked country with limited access to international markets, it became very important for Uzbekistan to ensure its food security through domestic production.

Over the decades, Uzbekistan's agricultural policy was characterized by full Government control over agricultural production and marketing. Land is owned by the Government as enshrined in the Constitution. The Government distributes land to farmers and determines the agricultural commodities to be grown under Government quotas (public procurement contracts). Two of the Government's major goals were to increase the much-needed foreign exchange revenue through the export of cotton, and to increase self-sufficiency in wheat production - thereby reducing dependence on imports. However, this inadvertently led to monoculture of cotton and wheat in most of the country.

Currently, about 80% of the total irrigated area is occupied by cotton and wheat, and most Government efforts are aimed at increasing the productivity and production of these two major strategic crops. Bread wheat is an important food staple in Uzbekistan, which, during the FSU era, was imported from other republics, including Kazakhstan. After independence, wheat became the second most important crop after cotton as part of a national 'self-sufficiency' campaign. Consequently, irrigated wheat area increased significantly from 0.63 million ha in 1991 to 1.31 million (82% irrigated) in 2019. During this period, average yield increased from 1.34 to 4.65 causing total production to increase from 0.95 million tons to 6.09 million tons. While area expansion contributed to the disproportionately high increase in total production, increases in productivity, which in turn is mainly driven by the expansion in irrigation, and the use of improved

varieties and associated management practices, is the main driver of the productivity increases.

Over the years, Uzbekistan went through several reforms and land reallocations (WB et al., 2019). The Government farm consolidation between 2008/2009 and 2016, created a dual system (Mirkasimov and Parpiev, 2017). In this system, smallholder farmers (commonly known as dehkan[1]) cultivating an average area of 0.5 ha and producing livestock and horticulture products, co-existed with large private farms, averaging 40-60 ha. The large public and private farms lease land from the government with a contract which is renewable and produce only cotton and wheat under a centrally planned system, where the state gives production orders. The 2019 restructuring doubled the size of cotton and wheat farms to an average of 100 ha. On the other hand, leases for dehkan farms are lifetime holdings and can be transferred through inheritance and they are free of quota system allowing them to produce crop of their choice.

1.2 National development strategy

In February 2018, the former Ministry of Agriculture and Water Resources (MoAWR) became two ministries, namely: the Ministry of Agriculture (MoA) and the Ministry of Water Resources (MoWR). The MoA deals with the agri-food supply system. Another Government body called Inspectorate for Control of Agro-Industrial Complex for ensuring food security was also established under the Cabinet of Ministries (Prime Minister's Office).

On February 7, 2017, "The Uzbekistan Development Strategy for 2017-2021" was adopted by Presidential Decree. The strategy's five main pillars seek to:

1. Increase the efficiency of the agricultural sector.
2. Improve the welfare of the population.
3. Reduce Government involvement and promote the private sector's role in socio-economic development.
4. Improve the investment climate and attract investments.
5. Promote public-private partnerships, increase the roles of non-Governmental organizations, and expand cooperation with international development institutions.

The main objectives of the rural development strategy of the policy include:

(i) Deepening the structural reforms in the agrarian sector and the diversification of agricultural production.
(ii) Accelerating sector modernization.
(iii) Promoting the development of the food industry, including processing of local agricultural raw materials.

[1] *Small farms or household plots not less than 0.3 ha*

Financial support to medium and small size businesses, including dehkans, is among the priorities for developing the banking sector. In a national drive for food security, the country has set a clear goal to liberalize its agricultural sector by reducing the role of the public sector and encouraging private sector investment. The economic liberalization, coupled with the country's policy and regulatory reforms, had serious effects on how the agricultural sector in general, and the seed sector specifically, was organized.

1.3 Agricultural development strategy

Presidential Decree #5853 (October 23, 2019) adopted Uzbekistan's Agriculture Development Strategy for 2020-2030. The strategy has defined priority areas, particularly developing and implementing national policies on food security, food safety, improved diets, and food self-sufficiency in the country. To create a favorable agri-business climate and value chain, the strategy envisages introducing market principles for buying and selling agricultural products, developing a quality control infrastructure, export promotion, and producing competitive commodities with high added-value. The strategy outlines a gradually decreasing role for the state in the agricultural sector. At the same time, it envisages to enhance the investment attractiveness of the industry to increase private investment to modernize, diversify, and support the stable growth of the agri-food sector. The strategy also promotes a rational use of natural resources, improved environmental protection, and implementing rural development programs. It also focuses on R&D, education, information, and advisory services in the agriculture sector. The strategy also strives for more efficiency and phased redistribution of Government spending, with sectoral programs aiming to increase labor productivity in farms, improve product quality, and create high added-value. Creating transparent sectoral statistics, providing reliable methods to collect, analyze and disseminate statistical data using digital technologies are also part of the plan.

The same Government decree approved the composition of the council to coordinate the strategy's implementation. Assigned by the Prime Minister, the MoA is responsible for overseeing overall progress and as quickly as possible, forming working groups including, among others, foreign experts, for each of the strategy's key areas.

Measures to support domestic exporters and enhance foreign economic activity (Presidential Resolution #PD-3077) was adopted on June 21, 2017. As one of the newest resolutions, it clearly demonstrates the shift in Government policy towards integrating the country's agricultural sector into the global economy. It removes restrictions on farmers to sell their produce exclusively to state procurement enterprises at fixed prices and allows them to export fruits, vegetables, grapes, and lemons directly and at market prices[2].

The resolution gives relevant ministries responsibility for submitting proposals, with

[2] *The resolution still has limitations, where farmers can export only on the basis of 100% prepayment and upon approval by the Advisory Council*

immediate effect, to prepare legislation and practices that comply with international plant quarantine (plant protection) standards, although no significant changes have happened so far. The Government gave a direct order to develop adequate infrastructure for plant protection (quarantine measures, laboratories, border control) and implement reforms required at legislative and institutional levels. The resolution also aims to promote the role of the private sector in agricultural production and trade. The private sector is generally weak due to the Government's monopoly power on state procurement contracts. The latest Government resolutions and Presidential decrees indicate a shift in Government policy to more inclusive and innovative trade in agricultural products.

By administering all lands, the Government has a major role in the agricultural sector. Farmers are granted usufruct land rights through lease contracts that have a 50 years term, but they're directed which crops to grow to achieve specific national production targets. Target production levels are established for major crops like cotton and wheat based on the agro-ecological zones, soil types, and access to irrigation. Farmers are required to sell a quota of at least 50% of their production at fixed Government prices which are announced at the beginning of the season. Farmers have the option of selling their surplus (over the 50% quota) to the Government at a higher, but fixed, price. If they opt for it, farmers can also choose to sell the surplus in the open local market, often at a higher price, which is a significant incentive for farmers to improve productivity. For all crops included in the Government procurrement, farmers receive credits for seeds, fertilizers, and other inputs, which they repay when their harvest is sold to the Government.

1.4 Wheat value chain

Mirkasimov and and Parpiev (2017) categorized the stakeholders in the wheat value chain into four groups:

(i) Governmental entities at national and regional levels represented by the state-controlled joint-stock company (Uzdonmakhsulot). It is comprised of 44 state mills and responsible to purchase and store wheat, and produce flour and wheat products and sale at subsidized prcies
(ii) Farmers, represented by about 60,695 commercial farmers specializing in the production of cotton and wheat, with an average farm size of 52.7 hectares. Commercial farmers do not own land—rather lease from government, and the lease contracts specify areas sown with cotton and wheat.
(iii) Private millers represented by a total of 60 private mills with a combined processing capacity of up to 2 million metric tons of wheat per year which are are also equipped with newer equipment and can produce a wider range of wheat products.
(iv) Consumers, namely, the entire rural and urban population who has access to subsidized wheat bread and products

1.4.1 Wheat grain production

During the FSU era, Uzbekistan imported most of its wheat from other Soviet Republics including Kazakhstan. When the Soviet Union broke up in 1991, traditional trade and political relations were dissolved. It forced Uzbekistan to devise a strategy of its own to source wheat from domestic production. The Government embarked on a new "independence in cereals" policy in 1993 and "self-sufficiency in wheat" in 1994. Since then, efforts have been made to increase wheat grain production through state orders to expand wheat area and by providing agricultural support (seeds, fertilizers, fuel) and low-rate credits from the Government for each production year.

The agricultural development policy for achieving food security and economic development enabled rapid progress in the wheat sector. Since independence, wheat is has the second most important crop after cotton. Wheat is included in the mandatory rotation system with cotton, and the state controls production and marketing of both crops. Wheat production is all about food security, which makes it politically sensitive. And being part of the state-regulated production system, any reform requires strategic thinking, careful consideration of pros and cons, and setting of priorities. Replacing the current regulated system, in particular, with fully market-oriented system will not be easy, as it requires major changes in overall agricultural policy, making it unlikely to happen in the near future.

There are Presidential decrees to eliminate the outdated state-production targets and procurement prices for wheat. There is a desire to replace the old state order system with a new arrangement of public grain stocks. The Government aims to achieve food security through sustainable increases in wheat production, mainly by increasing productivity through crop intensification, together with improved agricultural practices involving improved varieties and integrated crop management.

Other measures to increase wheat production include introducing the cluster system in the sector, based on Resolution #806 of the Cabinet of Ministers (September 26, 2019). It aims to optimize use of farmlands by increasing the size of farms producing wheat, re-allocating land to more efficient clusters, and improving crop rotation options. The state and local Governments were piloting projects to support the agricultural reforms and crop production. Several projects financed by bilateral and multilateral donors will serve as technical references on the initiative's feasibility. Under these arrangements, wheat clusters will buy wheat grain directly from farmers at fixed prices, process, and sell it in domestic and international markets.

As part of the initiative to ensure national food security, the area under irrigated winter wheat in Uzbekistan has dramatically increased more than five-fold, from about 0.25 million hectares in 1991 to about 1.15 million hectares in 2018. This accounts for nearly 35% of total arable land[3] (Figure 1.2). This increase occurred because the former long-cycle cotton-alfalfa cropping system was largely replaced by the shorter-cycle

[3] *Total irrigated area varies from 4 to 4.2 million ha depending on water availability during the season*
Source: Uzbek State Committee on Land Resources (2018)

spring cotton-winter wheat crop rotation system. This stimulated modern production technologies in the wheat sector, particularly the development and adoption of modern wheat varieties and associated crop management practices. Ultimately, this led to a substantial increase in wheat productivity (Figure 1.1).

According to MoA (2017), about 80% of wheat is produced by relatively large farms which, are on the average 50 ha in size and leased on a renewable contract from the government. These farms produce most of the wheat and are subject to the state order or quota system for production and marketing. Under the state quota system, these farms are obliged to sell 50% of their produce to the Government at a fixed price of 503,000 Soum ton^{-1}. The remaining half they can sell at open market prices, which in 2018, was 1,500,000 Soum ton^{-1}. About 18% of the remaining wheat is produced by small (dehkan) farms, with average farm size of 0.5 ha, and 2% by large specialized agricultural enterprises with land sizes between 200^{-1},000ha. These specialized enterprises primarily produce grains, but sometimes seed. Like the small (dehkan) farms, the specialized farms aren't part of the state order system.

Annual wheat production has increased by over six-fold from 0.95 million tons in 1991 to 6.16 tons in 2020 (Figure 1.1). This increase is mainly due to area expansion and yield gains from introducing new productive, improved varieties and intensive crop management practices. In 2017-2018, domestic wheat production accounted for more than 70% of domestic consumption for food and feed in the country.

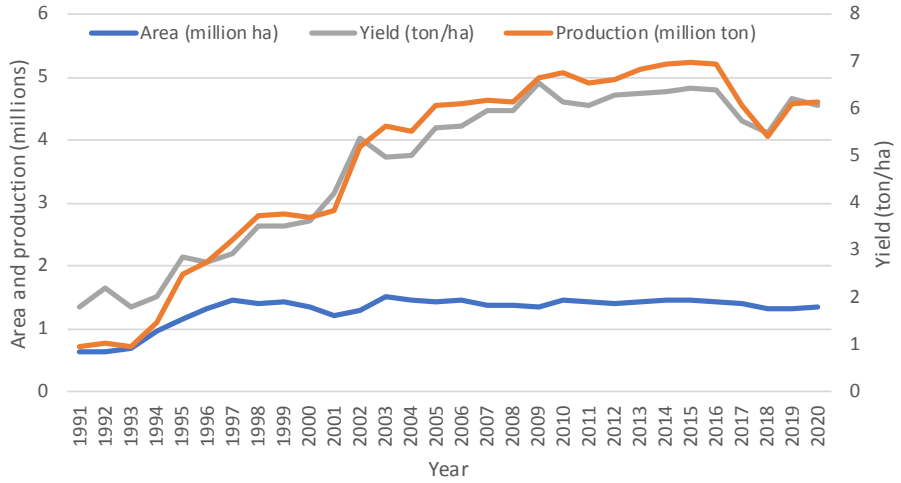

Figure 1.1. Area, yield, and total production of wheat in Uzbekistan (1991-2020)
Source: FAOStat (2022) for 1992-2020 and MoA (Personal Communication) for 1991

Generally, Uzbekistan's average yield is no lower than the global average, but the yield appears low considering irrigated environments only (Figure 1.1). On 17% of wheat growing areas in the country, the average yield was less than 4 ton/ha, below the national

average. An average yield of 4.1 to 5.0 ton/ha was seen on 20% of wheat growing areas (Table 1.1). The average yield was over 5 ton/ha on 62% of wheat growing areas and the average yield exceeded 7 ton/ha on 10% of wheat growing areas, particularly in the fertile Fergana Valley.

Table 1.1. Average wheat grain yield distribution in different regions of Uzbekistan (2018)

Regions	Area ('000 ha)	Total production ('000 tons)	%age of wheat area with different yield levels						
			1.0-2.0 t/ha	2.1-3.0 t/ha	3.1-4.0 t/ha	4.1-5.0 t/ha	5.1-6.0 t/ha	6.1-7.0 t/ha	>7.1 t/ha
Karakalpakstan	53.0	187.1	5.4	62	28.5	7.7	1.8	0	0
Andijan	78.2	450.4	0.4	1.3	12.5	9.6	18.7	48.8	9.1
Bukhara	63.1	353.4	0	0.8	7.4	14.7	27	41.5	8.6
Djizakh	104.0	436.9	0.3	5.9	20.6	32.8	31.9	8.8	0
Kashkadarya	143.0	601.5	0	2.6	9.1	15.9	23.6	34.1	14.7
Navoi	40.6	190.4	0.6	3	15.5	26	24.6	22.9	8
Namangan	76.5	382.5	0.4	1.2	4	11.4	35.7	21.6	26.1
Samarkand	105.7	454.7	0	2.1	12.9	32.6	35.6	16.8	0
Surkhandarya	95.0	410.4	0	0.9	18.9	37.5	31.8	10.9	0
Syrdarya	86.5	377.6	0.3	5.8	20.6	32.9	31.9	8.8	0
Tashkent	119.1	633.3	0	3.9	6.1	15.8	39.2	35	0
Fergana	109.2	559.4	0.8	2.5	5.6	10.8	19.8	24.5	36.8
Khorezm	33.2	167.7	1	1.7	9.1	33.1	38.8	13.8	3.5
Total	1,107.1	5,205.1	0.5	5.3	11.8	20.6	27.8	24.8	9.7

Source: MoA (2018)

1.4.2 Wheat production costs

After the post-Soviet era reforms, all land belongs to the state, and farmers obtain long-term leases for use. There are large private farms and small (dehkan) farms. Large farms lease land which must be renewed, whereas dehkan farms are lifetime holdings and can be transferred through inheritance (Mirkasimov and Parpiev, 2017). With the exception of some smaller farms of under 10 ha for horticulture and and even fewer large farms of over 300 ha for livestock production, most private farms are 30-50 ha. The owner, or a full-time manager runs these farms. While managers are generally supposed to be agricultural university graduates with Bachelor's degrees or college diplomas who become specialized farmers, currently, up to 50% of them don't have an agricultural background or experience. This might provide part of the explanation for the below average yields. Currently, agricultural research institutes and the agricultural universities do provide extension services but they're deemed insufficient. So, in the absence of an effective national agricultural extension service, the lack of professional expertise and experience among a sizeable portion of farmers presents a major challenge to the overall effort to sustainably increase productivity. Understandably, a strategy is

needed to help build the capacity of underperforming farmers.

Even though the national average wheat grain yield is about 5.5 ton/ha under irrigated conditions, the yield in most farmers' fields is low. If farmers follow the recommended full packages of crop-management practices and have access to agricultural machinery, potential average yields of seven ton/ha are feasible (Khalikulov et al., 2016). However, achieving this would require conserted efforts to increase productivity on 90% of all wheat growing areas.

Most farmers usually sow winter wheat seed in standing cotton, and till the land after the cotton harvest to cover the wheat seed in the soil. In this system, quite a high seed rate (about 250 kg/ha) is used to ensure good plant population. In recent years, it has become possible to successfully sow winter wheat in standing cotton, and even at half the seed rate (120 kg/ha) if using modern no-till drills imported from Brazil. This technology helps to sow seeds at the proper soil depth with no seed loss to birds and saves seed cost, without impacting grain yields. No-till planting technology can also help ensure timely planting and lower production costs by saving on fuel for tillage.

The Government contracts private farms to grow wheat, at least 50% of which they are obliged to sell at a fixed price announced at the beginning of the season (for example, the Government price in 2018 was 750,000 UZS[4] ton^{-1}). In return, the Government provides the private farms low-interest loans (3%) and subsidized support (seeds, fertilizers, fuel). Moreover, the private farms are allowed to sell the remaining produce at local market prices – in 2018, this was 1,500,000 UZS ton^{-1}.

Small farms grow wheat mostly for subsistence and not as part of the Government contracts. These farms usually buy inputs from the market with no Government subsidy. Some farm operations are done manually with limited machine hire and low fuel costs. Small farms achieve higher yields due to better crop management practices and by using more fertilizers. These farms pay taxes at a rate of about 1,928,571 UZS per ha.

Analysis of gross margins in wheat production shows that private farms achieve a profit of about 273 USD ha^{-1}, while small farms achieve about 584 USD ha^{-1} (Table 1.2). This is equivalent to a gross margin-to-cost ratio of 0.74 and 1.07, respectively. The higher profitability of small farms is attributed to low machinery and fuel costs (as cultivation is mostly manual, using family labor, which is often not accounted for), higher yields due to better crop management practices, use of larger quantities of organic fertilizers, and higher prices as they sell in the open local markets. Production targets and mandatory sales for wheat are strictly controlled by local administration (called hokimiyats). The Uzbek State Agro-chemical companies (called Uzagrokhim) owned by the state, control the provision of inputs and instruct farmers on how to use them. Only the small (dakhan) farmers have freedom to manage their farms differently.

[4] *In 2020, the average exchange rate was 1USD = 9,850 Uzbek Soumi (UZS).*

Table 1.2. Gross margin analysis of wheat production by private and dehkan farms in 2017

Entity	Private farms			Dehkan farms		
	Quantity	Price (UZS)	Total (UZS)	Quantity	Price (UZS)	Total (UZS)
Revenue						
Average yield (ton/ha)	5.4			6		
Price (UZS)		503,000/ 1,500,000[5]			1,500,000	
Total revenue (UZS/ha)			**5,109,000**			**9,000,000**
Operational expenses						
Seed (kg)	220	1,000	220,000	220	1,500	330,000
Fuel (liter)	140	2,882	403,480	90	3,800	342,000
Machinery hire (lump sum)	1	315,000	315,000	1	125,000	125,000
Nitrogen fertilizer (kg)	500	667	333,500	500	940	470,000
Phosphorus fertilizer (kg)	200	1,700	340,000	200	2,100	420,000
Potassium fertilizer (kg)	20	800	16,000	20	1,100	22,000
Organic fertilizer (ton)	5	30,000	150,000	10	30,000	300,000
Chemicals (lump sum)	1	62,250	62,250	1	62,250	62,250
Irrigation (Som/ha)	1	32,000	32,000	1	32,000	32,000
Electricity (kwy/hour)	0	0	0	1	0	0
Labor (person/month)	1	300,000	300,000	1	300,000	300,000
Taxes (lump sum)	1	318,315	318,315	1	1,928,571	1,928,571
Other expenses (lump sum)	1	434,446	434,446	1	0	0
Total operational expenses (UZS/hs)			**2,924,991**			**4,331,821**
Gross margin (UZS/ha)			**2,184,009**			**4,668,179**
Gross margin (USD/ha)			**273**			**584**
Gross margin to cost ratio*			**0.7443**			**1.07**

Note: Exchange rate of 8,000 Soum per USD^{-1} in 2018

** Gross margin to cost ratio is defined as the additional income (in UZS) obtained for every 1 UZS cost incurred in production.*

[5] *Private farms grow wheat on a contract with the Government. They're obliged to sell 50% of the produce to the Government at a fixed price of 503,000 Soum ton-1 and sell the remaining half of the produce at the market price of 1,500,000 Soum ton^{-1}*

1.4.3 Wheat grain processing

Currently, wheat procured by the Government is milled by 44 public flour mills, part of the state enterprises, and the flour is used to produce subsidized bread. These mills compete with many private mills but unequally, because despite theoretical economies of scale, large public mills are not cost-effective clearly showing the need for restructuring. This undesirable environment might however delay the full liberalization of wheat prices originally planned for 2021 to ease the transition in privatizing the mills.

Mills usually mix locally produced Uzbek wheat with the relatively higher-quality imported wheat of Kazakh origin. This produces various flour types for domestic consumption. Over the years, Uzbek mills have increasingly imported Kazakh wheat, milled it, then exported flour to Afghanistan and other neighboring countries. Some of the flour produced from cheap wheat bought from local sources under the state order, is exported instead of sold in Uzbekistan. This increases the demand for domestic production.

Flour milling is competitive. Many small private flour mills compete with large state-owned mills, to supply small and large private bakeries with a wide range of flour products. Privatization of state flour mills is expected to increase competition and reduce average milling costs in the long run. In the absence of fixed prices for public mills, whether the cost reduction from fully privatizing large pubic flour mills will keep the free-market bread prices affordable for the wider Uzbek population is an empirical question.

1.5 Wheat Seed Sector

Figure 1.2 presents the governance of Uzbekistan's seed sector. The Ministry of Agriculture is responsible for the national seed sector, including variety development, testing, release, maintenance, and production of early generation seed (breeder and foundation) and certified seeds. There are two Deputy Ministries under the MoA: (i) Production Center for Agriculture and Food Supply, and (ii) Agrotechnologies.

The agricultural research institutes under Production Center for Agriculture and Food Supply, have a network of research centers or experimental stations across the country involved in both variety development and early generation seed (EGS) production. In total, there are six agricultural research institutes with 20 branches or experimental stations and universities involved in wheat research and seed production. The State Variety Testing Commission (SVTC) is responsible for registration and performance testing of new varieties using its own network of 12 experimental stations and 36 special variety testing sites.

The Seed Development Center (SDC) and the Grain Production Department (GPD), under the Agro-technologies sub-Ministry are both responsible for planning and producing certified seed. The SDC is responsible for overall coordination, planning and monitoring of seed production in the country. SDC has 13 provincial offices and 131 district offices operating under the provincial offices. The GPD is responsible for certified seed production, and works mainly with state elite seed farms and private sector contract seed growers. The Grain Production Joint Stock Company, under the Cabinet of Ministers, is responsible for seed processing, storage, and distribution.

The State Inspectorate of Agro-industrial Complex (SIAC) is responsible for seed quality assurance and certification. The State Inspection for Plant Quarantine is responsible for seed import and export, and operates under the auspices of the Cabinet of Ministers. On the other hand, the State Intellectual Property Agency (SIPA), under the Ministry of Justice (MoJ), is responsible for protecting plant variety rights.

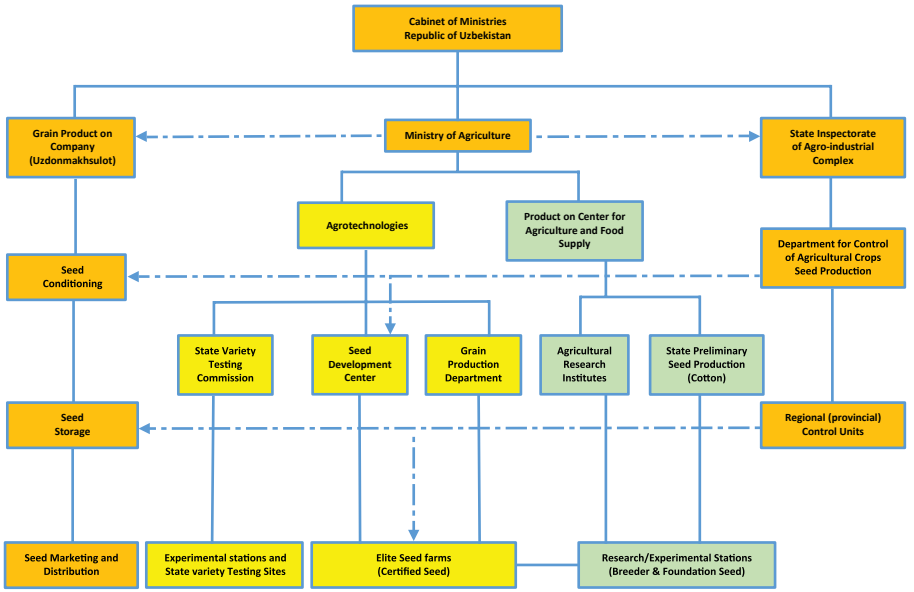

Figure 1.2. The organizational structure of the seed sector in Uzbekistan

1.5.1 Seed policy and regulatory frameworks

1.5.1.1 Introduction with historical context

In 1996, the Government of Uzbekistan adopted an agricultural development policy (Resolution of the Cabinet of Ministers #157 of 12 September 1996) to achieve food security and economic development. The policy rapidly increased wheat production, particularly by developing and adopting modern wheat varieties.

The Presidential Decree #5853 (October 23, 2020), defined the Agriculture Development Strategy for 2020-2030. The strategy, explained above, described the priority areas, particularly developing and implementing national policies on food security, food safety, and improved diets and food self-sufficiency. The decree also approved the composition of the coordination council to implement the strategy, and the assignment of the responsibility to the Ministry of Agriculture with oversight by the Prime Minister's Office.

1.5.1.2 National seed policy

A clear, stable, and consistent seed policy, with clearly defined functions and links between institutions and mechanisms for coordinating activities and monitoring progress of the national seed industry are essential for seed sector development. The national seed policy is one part of the Government's agricultural development and is a stable and long-term strategy to ensure optimal production and availability of quality seed to meet farmers' needs. To modernize the agricultural sector and ensure food security and economic development through a vibrant national seed industry, the Government adopted a seed policy in 1996 (Resolution of Cabinet of Ministers #328 of September 19, 1996). All seed production, imports, distribution and auxiliary operations in the country carried out by public agencies and domestic and foreign private companies, partially or fully, are subject to this policy. This policy has rapidly developed the seed sector, particularly in the development of several new improved varieties of wheat and cotton and spread the benefits of superior germplasm to farmers in all agricultural zones.

The policy stipulated private sector involvement in variety development and seed production with the main goal of creating easy access for farmers to quality seed. In October 1996, however, the Government took a historic step in the opposite direction proclaiming the "import substitution" policy. This hindered the transition to a market economy. Such a dramatic shift resulted in the agricultural policy to remain focused on cotton exports, with little-to-no attention paid to developing other agricultural crops, besides cotton and wheat.

After nearly 20 years, there are signs of gradual change in Government policy, specifically to reduce cotton monoculture and diversify crops, to ease up the Government's monopoly power in the agricultural sector, promotion for the export of agricultural products, and liberalizing economic policy towards more inclusive trade. The new developments aim to integrate the agricultural sector into global markets, which requires substantial reforms in the seed sector including plant variety protection, and phytosanitary measures.

To further develop the agriculture sector, a consultation meeting was convened with national and international experts. This culminated in the National Seed Forum held from January 31 to February 1, 2006, in Tashkent, to align policy with current international trends. The forum proposed revising and amending the legislative frameworks, based on the concept paper and consultative processes, to better align with the developments in privatizing the agriculture sector. The forum's recommendations led to revising the 1996 seed policy. This is consistent with changes that led to the transfer of state farms from public to private ownership and allowing commercial banks in rural areas to provide credits to local agricultural enterprises and enabling farmers to form family, group, or cooperative seed enterprises.

In 2014, FAO and MoAWR, in consultation with stakeholders, prepared and submitted a seed sector development strategy to the Government. The strategy contained the following key policy and legislative issues to help create a framework for the seed sector to transition to a market-oriented economy:

- Establish a National Seed Council to bring together the representatives of key seed sector stakeholders and to play a coordination function and work in crop sub-sectors.
- Ensure economic viability and financial sustainability of the national seed system, which will operate without state subsidies.
- Give priority and support to national breeding programs for both public and the private sectors, or a transition towards the latter.
- Encourage and support using appropriate genetic material from international agricultural research centers.
- Promote using traditional varieties in seed production and supply, provided they conform to national seed standards.
- Enable import of seeds if they conform to national seed standards, while preferably relying on domestic production by eligible seed enterprises or companies.
- Assign responsibility for seed production and processing to market-oriented commercial enterprises and encourage better marketing to reach more farmers.
- Support seed certification to enhance using quality seed, preferably focusing on domestic production involving both commercial seed companies and farmer-based seed enterprises.
- Support the purchase of equipment for seed processing and storage and training to enhance the capacity of human resources.
- Establish a seed producers' association to represent and promote the interests of commercial entities involved in the seed sector.

1.5.1.3 Seed regulatory frameworks[6]

The In the context of the national seed sector, the regulatory framework encompasses laws, regulations, procedures, and guidelines that govern the:

- Organization and management of variety development, testing, registration, and release
- Seed quality assurance
- International seed trade (import or export)
- Plant quarantine and phytosanitary measures
- International convention on intellectual property rights,
- Conservation of plant genetic resources, which directly or indirectly impact the exchange, and access to genetic resources; and
- Bio-safety on movement of the products of modern bio-technology, particularly genetically modified organisms.

The Seed Law #267-I (August 29, 1996), was a basic national seed law. It was amended by Law #252-I (April 25, 1997), Law #772-I – Chapter XV (April 15, 1999), and Law #521 (February 16, 2019). Law #521 (February 16, 2019), aimed to conserve and

[6] *All national seed laws, decrees, and resolutions referenced in the document are available at the National Database of Regulation of the Republic of Uzbekistan (https://lex.uz/). These can be searched in the data base by the Act #, Act Name, Date of Act and Act Type (legislative acts; presdential acts; acts of ministrers, departments or committes; international acts; and Government decisions)*

effectively use genetic resources; plant breeding for developing improved crop varieties; maintaining varieties and hybrids; producing and providing high-quality seed; achieving seed quality assurance and certification; and using new technologies in seed production and quality control. Government sources show there is currently an intention to revise the country's seed law.

In Uzbekistan, locally produced, imported, exported, or transited seeds are subject to compulsory phytosanitary and veterinary control in accordance with the Law on Agricultural Plant Protection #117-II (August 31, 2000) and Regulation on Procedure for Certification of Products (Annex to Resolution of Cabinet Ministers #318 of July 6, 2004), and Rules of Main State Veterinary Control Department (July 25, 2003). According to these laws and regulations, phytosanitary control and veterinary services are executed by MoA (ex MoAWR). According to Resolution of the Cabinet of Ministers of Uzbekistan #449 (December 5, 1995), the Main State Inspection of Plant Quarantine (MSIPQ) carries out phytosanitary control of seeds and issues the phytosanitary certificates for seeds exported, imported, or transited through Uzbekistan.

1.5.1.4 Institutional arrangements

Previously, the Ministry of Agriculture and Water Resources (MoAWR), now Ministry of Agriculture (MoA), is responsible for implementing Government policy and seed laws, rules and regulations in the agricultural sector. This includes crop production, livestock, veterinary services, phytosanitary control, water resources and sustainable rural development. According to the Presidential Decree #5330 (February 12, 2018), "Measures for Radical Improvement of Agriculture and Water Sector Governance"), the Ministry of Agriculture and Water Resources (MoAWR) was restructured into the Ministry of Agriculture (MoA) and the Ministry of Water Management (MoWM).

The MoA is responsible for research and development of the agriculture sector. This includes variety development, testing, and release, as well as seed production through its various departments. But seed processing, storage, and marketing through Grain Production Joint Stock Company (Uzdonmakhsulot) and seed quality assurance and certification through State Inspectorate of Agro-industrial Complex, remains the responsibility of the Cabinet of Ministers of Uzbekistan.

MoA works through national and regional offices. It's main tasks and scope of work are to:

- Implement a unified policy in agriculture and food security aimed at modernizing the sector through scientific and technical innovations in new resource-saving technologies, intensive agro-technologies, and best agronomic practices
- Coordinate state agencies, agricultural enterprises, and other relevant organizations dealing with food security in the country.
- Increase export potential by producing competitive products, conducting in-depth marketing research, attracting foreign investment, and gratuitous technical assistance (grants).
- Create the necessary stock of agricultural products and food stuffs year-round, and uninterrupted supply at stable prices to ensure processing of agricultural products.

- Improve mechanisms for public-private partnership, as well as enhancing participation of business entities in the country's socio-economic development.
- Develop integrated, targeted, sectoral, and national programs aimed at dynamic and balanced development of agriculture, food security, increased employment, improved livelihoods of rural population, and stable prices of food stuffs in the domestic market.
- Ensure systemic integration of education, science, and agricultural production and training and retraining of staff, considering current and prospective needs of agriculture for highly qualified experts.

1.5.1.5 Key challenges

Historically, agricultural production, processing, and marketing activities were governed centrally under a command economy. Despite several Government reforms since independence, certain features of the command economy remain. The Government procurement system still operates for some major crops, such as wheat and cotton, where farmers sell their produce to the Government through a quota system. The Government procurement contracts are for "Government use only" and not for commercial purposes where large state flour mills were selling, reselling, or processing products contrary to international law (e.g. WTO Government Procurement Agreement).

Currently, the wheat seed sector is planned centrally with the Government exercising monopoly power in both the supply and demand sides of the sector. Seed production is implemented through state agricultural research institutes and the Seed Development Center and Grain Production Department of MoA on public elite seed farms, or under contract with private elite seed farms. They sell seed under the quota system (see section 1.4.1) to a Grain Production Joint Stock Company ("Uzdonmakhsulot") responsible for processing, storage, and distribution. Farmers cannot sell wheat seed in the local market to any entity or farms. Such a centralized operation stifles private sector participation, which is contrary to the Government's seed sector liberalization and diversification policy.

1.5.1.6 Lessons learned

Uzbekistan made several farm restructurings, focusing on wheat and cotton crops. As a result, productivity and hence production increased, although over time agricultural productivity growth for several crops including what has slowed down and failed to reach the potential. The Government is willing to undertake new reforms based on lessons learned and experience gained over years. To that effect, a 2019 report by the World Bank, Swiss Confederation, IAMO, and USAID, recommends (and the authors of this chapter agree) that the future reform agenda should focus on:

(i) Removing production distortions.
(ii) Increasing public expenditure on agriculture to enhance sector performance.
(iii) Helping smallholders reduce transaction costs.

1.5.1.7 Recommendations

Consistent and stable national development, and suitable agricultural policies have played a key role in developing the country's wheat sector. There has been substantial expansion in area and increase in productivity and hence grain production over the years. Now, further improving the seed policy is needed to achieve sustainable crop production and increase the export potential of agricultural products – while ensuring sustainable use of natural resources.

The newly adopted agricultural development strategy requires new approaches in variety development and seed production to make room for the emerging private seed sector. First, new strategies need to be applied to cotton and wheat (the two strategic crops), while the evolving market trends dictate the selection of other targeted crops, as well as what types of changes to apply.

The Government plans to increase crop productivity and domestic production by encouraging the adoption of modern agricultural techniques. These include high-yielding varieties, selection and optimal application levels of agricultural inputs, and appropriate practices. And more so for wheat, as it's a strategic commodity for food security and economic development. To succeed, any wheat sector reform should consider developing the entire wheat value chain – from production to consumption. This includes the agro-industry (flour millers, and food factories) to make wheat production demand-driven. In other words, the reform must aspire to create a system where market signals are transmitted through traders to farmers who will have to make varietal choices and input decisions in response to the market incentives and disincentives. In such a system, end-users and hence farmers' trait preferences should dictate breeding objectives and hence the characteristics of newly developed varieties. Farmers' varietal preferences should also influence seed companies' decisions on seed production and commercialization. For such a reform to be effective, it must ensure an equitable sharing of benefits between all actors in the wheat value chain, including the research system.

Promoting new technologies would require appropriate policies on top of on-going efforts to privatize land, crop diversification, and investment in agriculture to link farmers to markets. Farmers' access to extension advice and training facilities to develop their business skills will also be important. This is because it's not just a matter of adopting technology but also applying management practices properly – not just to enhance productivity but to do it sustainably. For example, besides increasing productivity and reducing the application of nitrogen fertilizer in the subsequent wheat crop, legume-based rotation of wheat (with fodder legumes or pulses) is extremely important for managing soil fertility and health, and plant diseases, and should be adequately incorporated into the program.

To develop the national seed sector and align it with the global seed industry, the Government should seek membership of international organizations such as Organization for Economic Cooperation and Development (OECD), International Seed Testing Association (ISTA) and International Seed Federation (ISF). This will give the national seed industry access to necessary technical support.

There's a need to establish a national seed association, which can be instrumental in developing the sector and promoting the interests of all players in the seed system. Currently, there is no national association independent of Government to provide a forum to discuss seed industry issues, strengthen seed company capacity, represent seed company interests to the Ministry of Agriculture, or act for the national seed industry in regional and global organizations.

The Government should initiate and support efforts for regional harmonization, including establishing a regional seed trade association. Regional harmonization of policies and regulatory frameworks such as common protocols for variety release, seed certification, and phytosanitary measures to enhance seed trade with regional neighbors are important in paving the way to the eventual enhancement of regional seed security.

CHAPTER II

Variety Development and Evaluation

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2.1 Introduction with historical context

Uzbekistan has a long agricultural history, and crop cultivation has existed in the Aral Sea, Kashkadarya, Surkhandarya and Zarafshan basins and Fergana valley since ancient times. By the end of the 2nd millennium BC, the fertile soils and abundant rivers in Fergana Valley created a flourishing agricultural oasis, with the irrigation canals from the Karadarya river irrigating large areas (Tolstov 1948; Andrianov 2016). Wheat has been grown for thousands of years, and wheat landraces have evolved and characterized by drought tolerance, early-maturity and heat tolerance during the last phases of crop growth in the hot summer.

Agricultural research and plant breeding dates back to before independence. The former Central Asian Branch of All-Union Academy of Agricultural Sciences of the Soviet Union was responsible for breeding programs through a network of research institutes across Central Asian Republics (Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan). The history of wheat breeding in Uzbekistan goes back to 1909, when the Department of Dryland Farming of the Turkestan Experimental Station collected local landraces of wheat in Turkestan territory. During this period, the most common wheat landraces were Sary Magiz, Ala-Biruk, Kyzyl-Bugday, Nar-Kyzyl, and Ak Bugday (FAO, 2015).

The growing importance of breeding led to the establishing of two research institutes, namely: the Research Institute of Grain Production founded in 1913, and the Central Asian Branch of All Union Research Institute of Plant Industry established in 1924 (Hasan Yusupov 2019, personal communication). Before independence, a lot of attention on wheat breeding was on developing varieties for rainfed farming systems. Having said that, the Research Institute of Plant Industry worked on plant genetic resources conservation and breeding programs of wheat and other cereals in irrigated areas where it developed winter wheat varieties in the country (ICARDA, 2005) where it developed winter wheat varieties in the country.

Over time, the Grain Research Station (1913-1956) changed its name several times to the Research Institute of Rainfed Farming (1956-1992), the Research Institute of Grain Production (1992-1997) and, ultimately, became the Research Institute of Cereal and Legume Crops (RICLC)[7] . Until independence, the research institute carried out breeding for rainfed and irrigated areas including both bread and durum wheat, triticale, barley, maize, legumes, soybean, and peas (Sydykov et al., 2014).

The current wheat improvement program started in the early 1990s after independence from the FSU. The national plant breeding program in Uzbekistan was established and facilitated, in part, with support from the International Winter Wheat Improvement Program (IWWIP), based in Turkey. Since 1998, the CGIAR System-Wide Program for CAC and its Project Facilitation Unit (PFU), based in Uzbekistan, has built a successful partnership among all stakeholders and ensured effective links with CGIAR and other national and international organizations. International collaboration was initially established with Gallayaral Research Institute of Grain Production (now part of Research

[7] *It became Research Institute of Rainfed Farming since June 2021*

Institute of Cereal and Legume Crops) and the Research Institute of Plant Industry, and later with Tashkent State Agrarian University and Gulistan State University.

Previously, wheat breeding and seed production were carried out by the Research Institute of Grain Production (until 1997). Currently, it is the responsibility of the Research Institute for Cereal and Legume Crops (Gallayaral Research Station). Since its inception, the institute has significantly contributed to developing improved varieties of wheat and other crops. Their research is mostly focused on dry areas working on rainfed wheat and other cereals, legumes, and oilseed crops. From 1991, the Gallayaral Research Station developed and released several winter wheat varieties.

To date, the Uzbek Scientific Production Center for Agriculture and Food Supply (USPCAFS) under MoA administers about 15 agricultural research institutes and public elite seed production farms. Several agricultural research institutions are responsible for wheat improvement, targeting the country's different agro-ecological zones (Nurbekov et al., 2006).

2.2 Regulatory frameworks

In 1997, the Research Institute for Cereal and Legume Crops under Irrigation (RICLC)[8] was reorganized and established in Andijan, by Presidential Decree #413 (25 August, 1997). The Decree established 11 new experimental stations distributed across 11 provinces to improve crops and seed sector development with the support of RICLC (https://lex.uz/).

The Cabinet of Ministers Decree #209 (16 September, 2008) established the South Research Institute of Agriculture (SRIA) in Kashkadarya region for irrigated areas in southern Uzbekistan. According to the Decree, three new experimental stations were established for the cereal and legume improvement program and seed production. Currently, SRIA focuses on maintenance breeding and crop management practices of cereal and legume varieties. SRIA collaborates with ICARDA, especially in variety development.

2.3 Institutional arrangements

In Uzbekistan, agricultural research is coordinated by the Uzbek Production Center for Agriculture and Food Supply. Agricultural research is primarily considered a public service. The Government is responsible for ensuring the national agricultural research system has adequate physical (facilities and equipment), financial, and human resources to undertake crop improvement for priority crops. The Uzbek Scientific Production Center for Agriculture and Food Supply (USPCAFS) under MoA, is coordinating all agricultural research in the country. Although Uzbekistan has a long agricultural research and plant breeding history – dating even long before independence – the current wheat

[8] *It become Research Instiute of Rainfed Farming (RIRF) since June 2021*

improvement program began in early 1990s after independence from the FSU. The Government has carried out several reorganizations of the research systems, and this still continues.

The major NARS working on wheat include the Research Institute of Cereal and Legume Crops (RICLC), which targets irrigated agro-ecologies. This is carried out by the Andijan Research Station. Research targeting the rainfed agro-ecology is carried out by the Gallayaral Research Station. The Research Institute of Plant Industry (in Tashkent) targets both irrigated and rainfed environments. Samarkand Institute of Agriculture (Samarkand), now a branch of the Tashkent State Agrarian University (Tashkent), targets the irrigated agro-ecology.

The Research Institute for Cereals and Legume Crops RICLC has the largest wheat breeding and seed production program, with experimental stations across all provinces of Uzbekistan. Initially, the former RICLC (now RIRF) works mainly with Krasnodar Research Institute for Agriculture, where many varieties from Russia have been introduced, evaluated, and released. Most of these new varieties are resistant to diseases and lodging which are important traits preferred by farmers. These varieties also have good yield potential under irrigated conditions, and have increased the average yield of wheat by almost two-fold since independence. The South Research Institute of Agriculture (SRIA) is working on irrigated wheat, barley, and legumes focusing in the southern part of the country.

Each year, ICARDA and CIMMYT provide elite lines of cereals and legumes. Through their support, a regional Yellow Rust Network for wheat has been established including breeders and plant pathologists. SRIA is working to develop rust resistant wheat varieties in Uzbekistan.

Apart from public agricultural research institutes, there are few domestic private seed companies (including one foreign private company from Turkey) involved in variety development in Uzbekistan. These private seed companies can introduce wheat varieties from abroad and release and register them for commercialization in the country.

2.4 Technical procedures

Plant breeders need to adjust their breeding objectives, selection strategies, and criteria to the new realities of farming systems, social demand, and national policies affecting agricultural production. In anticipation of changes in resources, climate, environmental regulations, consumer perceptions and demand, and by learning from past experiences, plant breeders could predict likely future scenarios and the plant varieties that producers and consumers will eventually prefer. In Uzbekistan, wheat breeding priorities and objectives focus on developing high and stable-yield varieties. These increase and even out production through increased productivity and intensification, using improved agricultural technologies. They also reduce the risk of environmental factors limiting yields under irrigated conditions. See Figure 2.1 for the current scheme of variety development.

Variety development

Variety development involves evaluating crossings made by the national breeding programs or introducing and testing elite germplasm from outside sources through bilateral and international collaboration. Previously, many foreign wheat varieties – mainly from Russia and Ukraine – were introduced to Uzbekistan and widely grown over large areas. For example, in 1997, all irrigated wheat area was cultivated with varieties introduced from Russia (Nurbekov et al., 2006). However, these varieties are not tolerant to high temperatures and diseases such as wheat rusts. Consequently, high and stable grain yield, superior grain quality, and resistance to prevalent biotic stresses, particularly rusts and abiotic stresses such as drought, heat, salinity and winter hardiness, are the primary objectives of the country's wheat breeding program.

National breeding program

Agricultural research institutes and universities either introduce and evlaute elite germplasm from foreign sources or use national crossing programs for variety development (Figure 2.1).. The elite germplasm introduced from CIMMYT, ICARDA, Russia and other sources are evaluated and released directly. These elite lines enter the national variety development program at the collection nursery stage and will be evaluated along with materials from the domestic breeding program.

The national crossing programs usually use locally available germplasm, introduced germplasm or their combinations. Once crossing is done to create new breeding lines they follow different breeding techniques such as pedigree, back crossing, and bulk selection in handling the segregating population for further evaluation under field conditions. After crossing, nursery selection becomes more rigorous in each successive generation. The first round of selection is generally for traits such as yield, straw strength, and days to maturity. As breeding materials advance, the breeders use disease epidemic conditions to evaluate for resistance of promising lines.

Following initial observation of crossing or collection nurseries, the most promising materials are advanced to the selection and control nurseries. At this stage, breeding lines normally reach F6 to F8 generations. Elite lines passing the rigorous selection process are advanced to the preliminary competitive yield trials and competitive yield trials. Here grain quality is evaluated, although some preliminary screening for quality (e.g. kernel hardness, and protein content) and yield potential are also carried out at earlier stages.

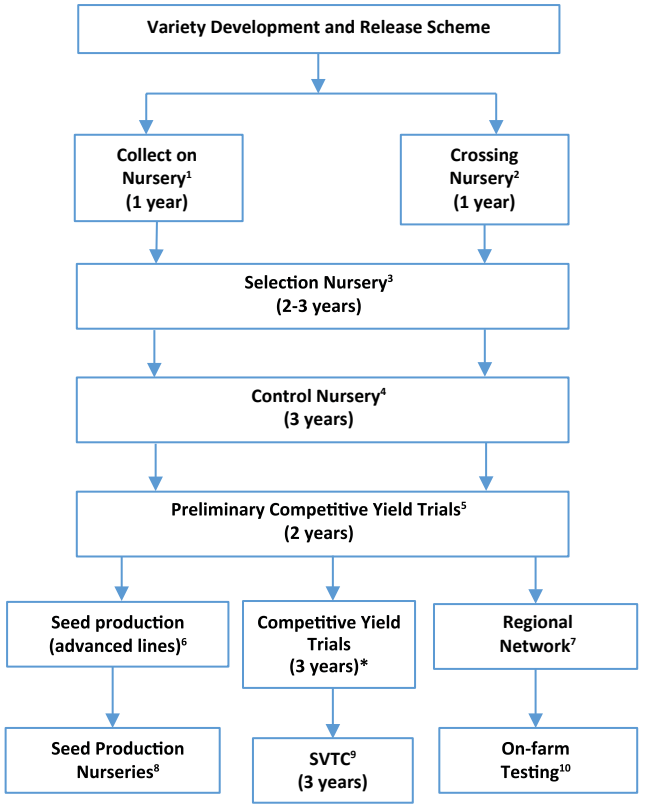

Figure 2.1. Scheme for variety development and release in Uzbekistan
Source: Seed Production Center, MoA

Notes

[1]Evaluation of national germplasm collections by NARS

[2]Making national crosses to create new breeding lines

[3]Preliminary observation of new crosses/lines

[4]Evaluation of segregating lines (F3-F6) in control nurseries

[5]Evaluation of stable lines (F7-F8) in preliminary competitive yield trials (+ grain quality)

[6]Seed production of advanced lines for submission to SVTC during competitive trials

*[7]Testing promising lines by ARIs in different agro-climatic zones at experimental stations as part of national competitive yield trials**

[8]Seed production of advanced promising lines while testing by the STVC which could be used for further multiplication upon release of varieties

[9]Testing for variety registration and performance by SVTC

[10]On-farm testing of new advanced promising lines by ARIs for agronomic management on-farm on contract with farmers

Subsequently, advanced promising lines from competitive yield trials are submitted to the State Variety Testing Commission (SVTC) for further testing (Distinctness, Uniformity and Stability (DUS) and Value for Cultivation and Use (VCU)) and release. Simultaneously, seed production of advanced varieties is done by agricultural research institutes based on the seed production scheme described in Chapter 4. When submitting advanced promising lines to SVTC for DUS and VCU testing, breeders must simultaneously transfer pure seed material of selected lines for preliminary seed multiplication.

During competitive trials, breeders should have at least two tons of experimental seed available on submission of a promising line to SVTC for testing in different agro-climatic zones. In the meantime, breeders should start seed production to have enough quantity for commercial production when the variety's released.

With the current state of variety development and release, it takes about 15 years to release a variety in Uzbekistan. However, there are discussions to reduce the number of years by eliminating or reducing the length of some trials.

2.5 Major achievements

The number and trends of bread and durum wheat varieties released in Uzbekistan is presented in Figure 2.2 and Annex 2. Annex 2 also has a list of released varieties categorized by their agronomic traits (yield, and plant height), resistance to biotic stress (rusts), abiotic stress (salinity, and cold), and grain quality (protein content, thousand seed weight, gluten content, gluten deformation index, and bread quality).

According to SVTC data, out of 184 wheat varieties (167 bread and 17 durum) released between 1940 and 2020 in Uzbekistan (Table 3.1, Figure 2.1 and Annex 2), those released before independence were limited. Thereafter, releases increased where, while only seven varieties were registered between 1940 and 1980, about 23 varieties were released between 1990 and 1999, 52 between 2000 and 2010, and 102 between 2011 and 2020 (SVTC). This clearly showed varietal release gained momentum post-independence. After independence, most wheat varieties used during the first phase of variety development were introduced from Russia (47) and other countries (32), whereas at the later stage most registered varieties were from national breeding programs showing the progressive changes in varietal portfolio. However, most wheat varieties were from the public sector and for irrigated areas, whereas only five were released from the private sector. Only 22 varieties were also released for rainfed areas.

Until 1997, many Russian and foreign wheat varieties were introduced and widely grown in Uzbekistan. However, this has changed with the release of newly developed wheat varieties by the national agricultural research systems. Several drought and salinity tolerant wheat varieties were released in collaboration with ICARDA and CIMMYT for both irrigated and rainfed areas. The number of varieties released through the breeding programs of NARS continue to increase, bucking the previous trend of introducing Russian varieties. Currently, there are 47 released varieties, of which 29 are

from the national breeding programs. For example, Gallayaral Research Station has so far developed 37 bread wheat varieties (15 for rainfed and 22 for irrigated areas), nine for durum wheat, 18 for barley, and several varieties of legume and oil crops (National Catalogue of Agricultural Crops, 2019). These varieties are resistant to biotic and abiotic stresses and lodging, and can better adapt to local climatic and environmental conditions.

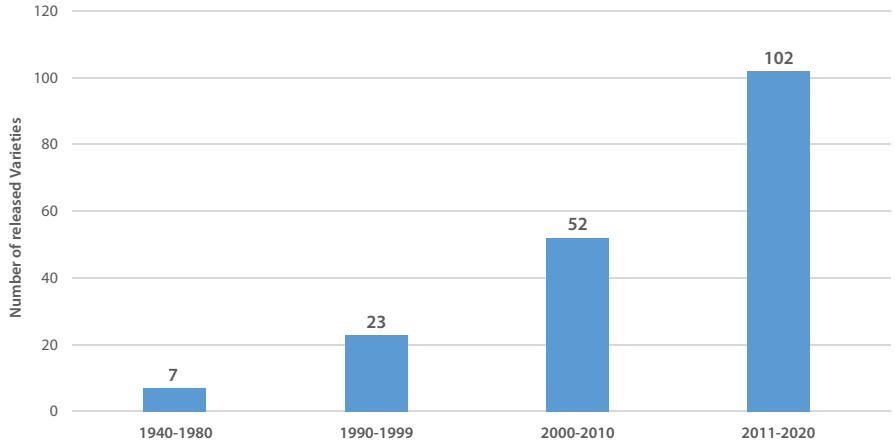

Figure 2.2. Trends of wheat varieties released in Uzbekistan (1942-2020)
Source: SVTC, 2021 (personal communication)

The MoA is entrusted to establish the Plant Breeding Development Association. The association's main purpose and task is providing support to the private sector and coordinating activities to develop and help private sector plant breeding, including infrastructure provision.

2.6 Key challenges

Variety development requires trained people who are able to apply modern breeding tools. Support is needed to exploit the full potential of scientific expertise at national level. The capacity to use new scientific knowledge in research for development is lacking locally, with the Government continuing to rely on the help of development partners for relevant training overseas.

Apart from people, NARS would need better physical infrastructure to conduct agricultural research and crop improvement work. Farm machinery, such as small plot planters, harvesters, and key laboratory facilities, are required to modernize plant breeding work. Available farm machinery and laboratory equipment are old and outdated and need replacing with new infrastructure. Moreover, the plant breeding and variety maintenance programs seriously lack financial resources.

Plant breeders need to define breeding objectives, and identify priorities and selection strategies to meet the challenges and consequences of climate change. In anticipation, plant breeders in Uzbekistan should envision future scenarios and develop wheat varieties that producers and consumers will prefer and which can adapt to likely emerging challenges and be tolerant to drought, cold, heat and salinity. Consequently, breeding objectives should be revised accordingly to meet emerging challenges.

The Law on Breeding Achievements provides overall direction for private sector participation in the agricultural sector, particularly to promote investment in plant breeding, though it requires revising and effective implementation. Despite the law, national breeders (authors of varieties) do not derive full royalty income from the use of their varieties, even when granted a certificate from STVC or patent certificate from SIPA because of an inefficient financial transfer system.

2.7 Lessons learned

The NARS has a long tradition in varietal development of strategic crops, such as cotton and wheat. Since 1914, several wheat varieties have been released and cultivated on a large scale, contributing to developing the country's agricultural sector. Uzbekistan has actively released varieties and made sure these varieties reach farmers. However, considering wheat is mainly produced under irrigated environments, the national average yield (4.7 tonha-1 in 2018) is much lower than the potential yield of 6-8 ton/ha (Khalikulov et al., 2016). Survey results also show farmers are not getting seed of varieties with their preferred traits. As such, concrete measures should be taken to match breeding objectives with farmers' and consumers' preferences and, ultimately, develop and release new varieties with desirable traits such as high yield and resistance to rust. There's also a need for NARS to develop an effective marketing strategy to ensure commercialization of their varieties.

The Government is paying more attention to strengthening the national crop improvement program and prioritizing developing locally adapted varieties to increase the productivity of winter wheat in irrigated areas. Continued Government investment in basic infrastructure for varietal development helped increase the number of released varieties adapted to local conditions from domestic breeding programs compared to varieties introduced from abroad.

2.8 Recommendations

Plant breeders are responsible for variety maintenance and early generation seed production. However, in practice, plant breeders do not pay much attention to maintaining their varieties. This limits the availability of early generation seed. This is crucial to commercialize new varieties and needs to be strengthened by the agricultural research institutes.

The partnership between public breeders in research institutions and private sector

breeders is poorly organized. Allowing national breeders to enter agreements with overseas private breeding programs or seed companies to take responsibility for introducing and releasing varieties and producing and marketing seed can be a viable option for strengthening the public-private partnership.

The Government directs public plant breeders to breed wheat varieties with certain traits such as yellow and leaf rust resistance, higher yield, and good grain-quality. This may not always fully reflect the traits farmers and processors are interested in. There is also no marketing strategy by NARS to promote using their varieties. It is therefore important to analyze and identify the traits desired by different actors along the wheat value chain (farmers, millers, bakeries, consumers, etc.). Such a study should also factor in variations across different agro-ecologies (irrigated vs. rainfed) and the socio-economic context of farmers. This will be useful to match breeding objectives to farmers' and end-users' trait preferences thereby further enhancing adoption of recent varieties.

CHAPTER III

Variety Release and Protection

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3.1 Variety release and registration

3.1.1 Introduction with historical background

Before independence, the variety release system was part of a larger entity responsible for all Former Soviet Republics (FSUs). However, after independence in 1991, Uzbekistan established its own variety release and registration scheme. For release and registration, new crop varieties developed by national plant breeding programs or introduced from foreign sources must go through two types of tests. First, is the distinctness, uniformity and stability (DUS) for plant variety registration. Second, is the value for cultivation and use (VCU) for ensuring variety performance. The tests are carried out by an independent or impartial agency(ies). The Government recognizes variety testing is a public-service activity, and so is conducted by public agencies, in accordance with specified protocols and procedures to ensure the release of superior improved varieties (ICARDA, 2005). In the past, only public breeding programs were allowed to register varieties in Uzbekistan. However, since the 2010s, both public and domestic private companies can register varieties with or without protection. Currently, five domestic private seed companies have released and registered varieties. So far, only one foreign private seed company registered a wheat variety.

3.1.2 Regulatory frameworks

According to Resolution #553 (Regulation 2 of 18 December 1997) (https://lex.uz/), the State Variety Testing Commission (SVTC) is a competent authority for variety registration and maintaining the National Crops Catalogue (called variety register book) pursuant to the Regulation for National Catalogue of Agricultural Crops Registered for Cultivation in Uzbekistan (2019). All crop varieties released and grown in the country should be included in the national variety register.

3.1.3 Institutional arrangements

The State Variety Testing Commission (SVTC), established in 1991, is a legal entity responsible for carrying out DUS and VCU testing, developing testing protocols and procedures, and organizing and disseminating relevant information on related issues. It's also responsible for maintaining the national variety catalogue of released varieties and publishes the variety register book for all released agricultural crops including both protected and non-protected varieties. SVTC provides the DUS data required for plant variety protection to SIPA, which publishes a list or catalogue for protected varieties.

Since 1991, the SVTC has introduced major reforms in its variety release mechanism, which previously focused on cotton only. Currently, it has extended the testing of cereal and legume crops to eight additional stations set up in different regions of the country. All wheat varieties developed by the national breeding programs, and those introduced by foreign seed companies, are subject to variety registration and performance testing by the SVTC before being officially recommended for growing in the country. To ensure VCU testing across different agro-ecologies, there's a network of 12 state variety testing

experimental stations and 36 special state variety testing sites across the country. DUS testing for registration in the country is, however, conducted in six locations (three irrigated and three rainfed areas) for two cropping cycles or two years for all crops. However, for wheat DUS testing is carried out in two locations (one each, in irrigated and rainfed areas). Maintaining the state variety register is financed by the state and includes registration fees, and fees for services and materials provided by the SVTC, but with approval from the MoA and consent from the Ministry of Finance.

3.1.4 Technical procedures

All crop varieties recommended for cultivation in Uzbekistan should be officially released and registered in the country. The promising lines from NARS or foreign breeding programs should be submitted to SVTC for further testing for registration and release. The SVTC conducts the following tests and examinations:

(i) Performance testing (value for cultivation and use or VCU) to determine its economic value for including in the variety register and for recommending whether it should be cultivated in Uzbekistan.
(ii) Registration testing using morphological description for establishing varietal identity (Distinctness, Uniformity and Stability – DUS).
(iii) Examination for granting plant variety protection to ensure patentability (DUS and novelty).

SVTC conducts DUS and VCU trials based on adopted experimental protocols at locations specified by it and the national variety release committee.

Application procedures

All varieties from national breeding programs or introduced from abroad by private seed companies can be submitted for registration in a national catalogue for agricultural crops in Uzbekistan. Foreign varieties are treated and tested under similar conditions as varieties from national breeding programs. Breeders apply directly or through their representative. Applications require:

(i) Declarations about the breeder.
(ii) Amount of seed, spikes, or plants submitted.
(iii) A certificate confirming that the variety is not a genetically modified (transgenic) organism.
(iv) Information about the variety (publications, prospectus, descriptors, commercial announcements, pictures, statistics, etc.) by specified dates, and completed on forms 295, 296, 297 and 301 (for wheat only).

DUS and VCU tests by SVTC are free of charge for release. This may encourage foreign breeders to submit varieties of benefit to Uzbekistan. There are rumours the Government may charge for testing foreign varieties. Currently, every applicant has to pay 150 USD for DUS testing, regardless of origin for variety protection only.

Testing for registration and performance

In Uzbekistan, two comprehensive tests are required for official wheat varietal release: DUS testing for variety registration and VCU testing for variety performance. These tests are carried out for no fewer than two seasons or two years.

Performance testing

Variety performance testing (often called VCU) is done to identify adaptation of new varieties to different agro-ecological regions in the country. It requires three years of field evaluation and extensive testing for agronomic characters. VCU trials are conducted according to SVTC's experimental protocol published in 1971. Trial design is randomized complete block design, with four replicates and a plot size of 25m^2. Fields are observed regularly and records taken for planting date, irrigation, pesticide use, and agronomic performance such as grain yield and quality, and tolerance to biotic (diseases and insect pests) and abiotic stresses.

Registration testing

Registration testing (often called DUS) is carried out using morphological characteristics to define the identity of a variety using descriptors developed by International Union for Protection of New Varieties of Plants (UPOV). Examination for DUS is done by specialized testing stations and organizations under the MoA, the list of which is approved by the Cabinet of Ministers. In general, wheat DUS testing is carried out in two locations, one in irrigated and one in rainfed areas.

Requirements for registration and release

MoA is responsible for approving variety registration and release and is supported by the national variety release committee and its crop sub-committees. The national variety release committee is comprised of representatives from the MoA, SVTC, State Inspectorate of Agro-Industrial Complex, breeders and seed producers from agricultural research institutes and private seed companies. There's also a sub-committee for each group of crops, which includes nearly all researchers.

Both registration (DUS) and performance (VCU) tests are run in parallel to make sure the results of both tests are available at the same time. Promising varieties that pass rigorous performance testing and meet registration testing requirements can be proposed at yearly meetings held in December by the SVTC. The sub-committee for each group of crops critically examines the performance data submitted to the SVTC and recommends the variety for registration and release. The sub-committee submits its recommendation for formal approval and release to the MoA. SVTC provides DUS and novelty data to SIPA for plant variety protection, which examines the application and grants protection. On MoA (release) and SIPA (protection) approval, the SVTC publishes the variety in a state register for agricultural crops. The SVTC register includes both released non-protected varieties (mandatory) and protected varieties (non-mandatory).

Registered varieties must have one or two better traits, match the same yield level, or not significantly inferior to those available in the register. All varieties are compared based on average yield across all provinces and sometime tested for special agronomic traits. However, each variety is recommended based on its performance in each agro-climatic zone, for example for irrigated and rainfed conditions. Varieties are also recommended regionally, and referenced in the variety catalogue to a particular province where they're recommended, hence address-specific adaptation.

The information required for registration of crop varieties recommended for commercialization include crop variety, applicant, address, country code and application number. Other information includes date of priority and variety registration, breeders of varieties, and name and address of breeder of varieties and the intermediary. Registration of varieties is carried out no later than six months after the decision to release by the SVTC and upon payment of appropriate registration fees.

Registration of a variety is valid for 10 years, which can be extended for up to additional 10 years. To extend registration of a variety, the following conditions must be fulfilled:

(i) Variety does not correspond to its description
(ii) Variety loses its value for cultivation
(iii) Variety is not used for more than four years
(iv) The applicant requests it

Registration fees are not paid for maintaining varieties in SVTC's register. Legal persons (individuals or institutions) that disagree with the SVTC's decisions have the right to appeal to the SVTC as set out by legislation. Unless a variety fulfills one or more of the criteria for de-registration listed above, its registration will be automatically extended.

3.1.5 Major achievements

Since 1991, the SVTC majorly reformed the variety release scheme, which previously focused on cotton only. To ensure testing across different agro-ecologies, there is a network of 12 state variety testing experimental stations and 36 special state variety testing sites, across the country. Together, these represent different environments and constraints in wheat production. For example, stations in Bukhara and Karakalpakstan conduct tolerance tests for salinity and drought.

To date, 184 wheat varieties (167 bread and 17 durum) were registered in the national variety catalogue from 1942 to 2019 (Table 3.1 and Figure 3.2). Among these, 91 bread wheat (12 rainfed) and 12 durum wheat (two rainfed) varieties are from Uzbekistan (50%), while the rest were introduced from abroad. Five bread wheat varieties were also from the domestic private sector. Conversely, 49 bread and three durum wheat varieties were introduced from Russia (28.3%) and 27 bread wheat and two durum wheat varieties were introduced from other countries (15.7%). Almost all domestic or foreign bread and durum wheat varieties were from the public sector, except five bread wheat varieties from the domestic private sector. Most varieties were for irrigated areas, with only 19 bread wheat and three durum wheat varieties adapted to rainfed

conditions, mostly from domestic public sector national releases (Table 3.1).

Table 3.1. Number of bread and durum wheat varieties released in Uzbekistan (1942-2020)

Crop	Country of origin	# of varieties	Sector	Remarks
Bread wheat	Egypt	5	Public sector	
	Kyrgyzstan	1	Public sector	
	Kazakhstan	1	Public sector	
	Russia	49	Public sector	
	Serbia	4	Public sector	
	Tajikistan	1	Public sector	Rainfed
	Hungary	2	Public sector	
	France	8	Public sector	
	Ukraine	3	Public sector	
	China	1	Public sector	
	Mexico	1	Public sector	
	Uzbekistan	91	86 public and 5 private companies	
	Sub-total	167		
Durum wheat	Russia	3	Public sector	1 rainfed
	Georgia	2	Public sector	
	Uzbekistan	12	Public sector	2 rainfed
	Sub-total	17		
	Total	**184**		

Source: SVTC, 2021 (personal communication)

3.1.6 Key challenges

Currently, SVTC conducts performance testing of new varieties using its own network of 12 experimental stations and 36 special variety testing sites. Procedures in the release system that require new varieties to perform across locations and have wider adaptations to be considered for release remains to be a major challenge. However, SVTC lacks human resources and physical facilities to cope with the increasing demand for variety release of newly introduced crops.

There are two variety registers maintained by the SVTC (under MoA) and the SIPA (under MoJ). SVTC is responsible for examining variety registration and maintaining a national variety catalogue for agricultural crops. STVC also issues certificates of breeding achievements for protected varieties. However, SIPA is responsible for the formal examination and maintenance of national catalogue for protected varieties. While SIPA is de jure responsible for protecting breeders' rights, de facto, it does not have adequate expertise (specialized staff and resources) to implement and enforce such policy. Recently, STVC established a new unit to handle DUS testing, which will be

SIPA's main focal point.

Separating functions for registration and protection of plant varieties between STVC and SIPA, respectively stipulated in the Law on Breeding Achievements, is not effective and does not conform to the UPOV Convention. UPOV stipulates for a single body with ultimate responsibility for protecting plant variety and enforcing breeders' rights to be authorized. Although enforcement is critical for IPR protection, neither SVTC or SIPA is authorized to enforce breeders rights, which leaves a vacuum and renders Plant Variety Protection (PVP) ineffective.

3.1.7 Lessons learned

Variety registration and release operates as an independent agency and is funded by the Government as a public service. Maintaining the state variety register is funded by the state budget, where registration fees, and fees for services and materials are covered by the SVTC, and approved by the MoA with the Ministry of Finance's consent. Having no variety testing fee encourages many national and foreign breeders to submit several varieties. While this is generally good, it might put more pressure on the country's limited testing capacity. Many specialists from SVTC propose introducing a variety testing fee for foreign breeders and private companies. This is currently under discussion.

At the moment, SVTC conducts the performance testing of new varieties using its own network of 12 experimental stations and 36 special state variety testing sites. The procedures for release system require new varieties to be tested across locations to identify varieties with wider or specific adaptations as varieties are released in regions or provinces. However, it's worth rationalizing the need and effectiveness of such a large network of sites and its physical, financial, and human resources implications for managing the system.

3.1.8 Recommendations

In order to increase Uzbekistan's benefit from its breeding efforts and regional trade, it is advisable to draft new or revise the law on breeding achievements, as follows, to bring it in line with the provision of the UPOV Convention:

(i) Align terms with UPOV definitions.
(ii) Substitute IPR legislation (patents and license agreements) by priority rights and notifications.
(iii) Include a provision on national treatment, as required by UPOV Convention.

PVP is an important provision, especially considering current developments to attract investment, promote exports, and liberalize imports in the agricultural sector.

Currently, there are two institutions implementing plant variety registration and protection. SVTC is responsible for variety release and testing for protection, whereas SIPA is responsible for variety protection only. These organizations are placed under two different jurisdictions. SIPA does not have the technical capacity to handle variety testing for protection. Plus, it doesn't have technical capacity to enforce PVP. Therefore,

it's advisable to consolidate and streamline the administration of national crop variety registration and protection of agricultural crops. It is recommended that responsibility for registration and PVP is given to SVTC, but its capacity (expertise and resources) needs to be increased to enable it carry the responsibility as is practically implemented in many countries. Otherwise, the functions of SVTC (variety registration) and SIPA (PVP) should be clearly understood and coordinated to achieve a unified policy of PVP enforcement and ensure conformity with UPOV.

Variety testing and release are normally carried out for major field crops such as wheat and cotton. Recommendations include:

- Establishing a strong link between plant breeders and SVTC technical staff, to provide technical guidance and supervision to improve technicians' skills in variety testing
- Introducing a coding system during registration and performance testing to avoid bias and ensure impartiality of the release process. Current practices carry the risk of revealing the company's or breeder's identity.
- Initiate collaboration in DUS testing with plant breeders from agricultural research institutes and seed companies. This will strengthen capacity and reduce costs as seen in other countries.

3.2 Plant variety protection

3.2.1 Introduction with historical context

In 1991, right after independence, Uzbekistan became a World Intellectual Property Organization (WIPO) member. The Presidential Decree #1536 (May 24, 2011) established Uzbekistan's State Intellectual Property Agency (SIPA) (https://lex.uz/). It was set up under the Ministry of Justice (MoJ) by merging the State Patent Office and the Uzbek Copyright Agency. SIPA implements a single and unified national policy on intellectual property and international treaties on IPR, creating favorable conditions for effective use of scientific and technical creativity.

SIPA is entrusted with several important tasks in IPR protection in its broadest sense, which could be scientific, technological, or artistic. These cover inventions, industrial designs, utility models, trademarks, artistic and other IP objects. Breeding Achievements is one of the IPRs related to developing new crop varieties. Uzbekistan became the 57th member of the International Union for Protection of New Varieties of Plants (UPOV) in October 2004. The law on breeding achievements for new crop varieties registration and granting plant breeder's rights is in line with UPOV Convention. The law also gives the public or community the right to authorize local landraces and wild species found in their habitats.

3.2.2 Regulatory frameworks

From the outset, Uzbekistan paid greater attention to developing science and

technological innovation and established legal mechanisms to protect intellectual property rights. Accordingly, the Presidential Decree on "State Support of Scientific and Innovative Activities" #3451 (August 8, 1992), strengthened scientific and technological innovations and addressed priority issues of economic and community development. Uzbekistan is one of the first countries of the Commonwealth of Independent States to initiate innovation policy.

The Government enacted a plant variety protection law entitled, Law on Breeding Achievements #395-II (August 29, 2002) to regulate intellectual property rights and provides legal basis for PVP to encourage private sector participation in agricultural research and development. The law covers procedures for testing and granting PVP, plant breeder's rights, and the patent office-State Register of Plant Varieties of Uzbekistan (Directive #5 of September 15, 2003). According to the law, any natural person who breeds a new variety of plant (or new breed of animal) shall be granted protection for selection attainment. Natural people taking part in creating a selection attainment, shall be admitted as co-authors and rights shall be determined by legislation and agreement among them. The Law also stipulates procedures for patent application, requirements for applicants, priorities in patenting, public examination of a selection attainment for patenting, final examination, and temporary legal protection of a selection attainment submitted for patenting.

IPR reforms are aimed at strengthening its implementation and public administration. According to the Presidential Decree #4168 (February 8, 2019), recognizing its unsatisfactory performance in IPR protection and implementation of international standards, SIPA was transferred to MoJ. Presidential Resolution #PD-4380 (July 1, 2019) re-organized SIPA under the Ministry of Justice (MoJ). The reforms aimed to enhance the public administration of IPR and may increase interest in investment in the country.

3.2.3 Institutional arrangements

According to the Law on Breeding Achievements, the entity authorized to implement plant variety protection in Uzbekistan is the State Intellectual Property Agency (SIPA), under Ministry of Justice (http://www.ima.uz/en/). Currently, however SVTC under MoA is conducting DUS testing for protection of varieties for breeding achievements and provides all data to the SPIA. Accordingly, SIPA implements a national policy for legal protection of breeding achievements, develops formal examination procedures for granting protection, and is also responsible for variety protection. It receives applications and conducts formal examination for protection, issues protection certificates, keeps official publications on applications, registers breeding achievements, and maintains the state register of protected varieties. SIPA also publishes the official data of legal protection on breeding achievements on its website. It also collaborates with similar offices and international organizations in accordance with the international treaties signed by the country.

Unlike DUS tests for registration, there is a fee if variety protection is needed. To facilitate the work of SIPA, there are patent fees of 250 USD for legal entities and

non-residents and 150 USD for legal entities and residents of Uzbekistan. Fees are paid every two years to maintain the variety in the list of protected varieties, until the date of protection expires. Payment for registration of protected varieties, penalties for administrative offenses, and for other services are listed in SIPA's budget. The budget is for strengthening physical and technical services and costs (compensation, salary, and social protection) of SIPA employees.

The Seed Development Center (SDC) enforces the payment of royalties for protected varieties from public and private sectors. The SDC is encouraging plant breeders to develop new wheat varieties to increase production in the country.

3.2.4 Technical procedures

SIPA receives and examines breeding achievement applications including inventions, utility models, industrial designs, trademarks, appellations of origin, and topographies of integrated circuits. It also registers grants, patents, and certificates, maintains a registry of subject matters, provides rights on use, and registers license agreements and open licenses in line with established legislation.

Application for breeding achievements

In Applications and attached documents for breeding achievements can be submitted in Uzbek or Russian. The application is submitted according to the state service standard for registering with granting the right to use a trademark, breeding achievement and object of industrial property, and the state service standard for registering the transfer of exclusive rights to a trademark, selection achievement, and object of industrial property.

The documents submitted with the application form include:

(i) Document confirming payment
(ii) Agreement granting the right to use an object or a certified copy of the contract
(iii) Copy of the power of attorney, if the application for providing public services is submitted through a representative
(iv) Document granting waiver of own rights to allow use by the public sector.

The service should be provided within 10 working days from the date of receipt of the application. This period is calculated from the day of receipt of the application and the documents attached to it. It can be extended for up to three months if the applicant needs to submit missing or corrected documents, or make necessary changes and additions.
A patent for breeding achievements is issued to:

(i) Author (co-authors) of a breeding achievement or their successor(s)
(ii) Legal entities and (or) natural persons (at their consent), indicated as author or their successor in application for patenting, or in the application for change of the applicant, submitted to the Patent Department of the Agency before registration of a breeding achievement; and employer, in cases, stipulated by Article 7 of this law.

Protection is granted to a breeding achievement, if it meets the criteria for novelty, distinctiveness, uniformity, and stability. Both the protection and right of priority is provided according to the UPOV Convention.

SVTC registration is a single copy consisting of several files, each of which reflects certain actions made with breeding achievements during its existence. A final decision on including or excluding a variety from the register is attached to a string, numbered, and sealed, and the book kept in the Department of Registration for new [agricultural plant] varieties and hybrids. All information necessary to distinguish a variety from other varieties is entered in the Register.

Examining applications

Examination of applications for a breeder's right consists of two steps: (i) formal examination and (ii) substantive examination. The formal examination involves reviewing all necessary documents for application, establishing a priority date, and making decisions within two-months. An applicant is notified in writing of the result of their formal examination. If they disagree with the decision they can appeal to the Appellate Council under the SIPA.

Substantive examination for granting a patent consists of (i) examination for DUS criteria (distinctiveness, uniformity, and stability) and (ii) examination for definition of novelty. SVTC conducts the examination of DUS criteria in line with the UPOV Convention. Moreover, examination for the definition of novelty is conducted by specialized stations of SVTC for specific crops, based on documents and existing evidence. The specialized stations inform SIPA of their findings. Any legal person can appeal the novelty of the application to SIPA within six months from the publication date.

The Law on Breeding Achievements provides provisional protection of a breeder during the period between the filing or the publication of the application for granting breeder's right, and the grant of that right. This provision conforms to the UPOV Convention on provisional protection.

Granting protection

The DUS and novelty examination are carried out by SVTC specialists and approved by SIPA specialists. According to the law, if all four criteria (distinctiveness, uniformity, stability and novelty) are met during substantive examination, the legal protection of a breeder's right is confirmed with the issue of a patent. However, if only two of four criteria (uniformity and stability) are met, then a breeder is protected by a certificate. Both a patent and a certificate are issued for 20 years from the date of registration in the SIPA Register. Both holders of a patent or a certificate enjoy the protection of the right for designated variety denomination to own, use, and dispose of the breeding achievement. The UPOV Convention makes no differentiation between types of protection documents and conditions if all four criteria are met and granted a breeder's right.

3.2.5 Royalty payment

There is no practical variety licensing system in Uzbekistan. However, there is an honorarium paid to breeders to strengthen the capacity of human resources and facilities of research institutes and seed producers entirely controlled by Government. The amount allocated is up to 3% of certified seed sold by the Grain Production Joint Sstock Company (Uzdonmakhsulot). This allocation follows the Resolution of Cabinet of Ministers #376 (August 6, 2004) and joint Decree of MoAWR #3/1 (May 30, 2012), the Ministry of Finance (#45 and #7), Ministry of Economy and MoJ #2382 (July 25, 2012). Up until 2012, Uzdonmakhsulot transferred the royalty fee to a special account of the Research Institute of Cereals and Legume Crops (RICLC).

Currently, royalties are paid directly to the wheat breeding agricultural research institutions such as RICLC (now Research Institute of Rainfed Farming since 2021) and South Agricultural Research Institute. The transferred amount (100%) is calculated and distributed as follows:

- 30% to wheat research institutes to support breeding and seed production and to strengthen facilities and technical capacity to encourage research institutions to produce seeds of national and foreign varieties.
- 50% to regional branches of wheat research institutes to support breeding and seed production, and to strengthen facilities and technical capacity to encourage research institutions producing seeds of national and foreign varieties.
- 10%[9] to originators (breeders), scientists in the breeding-team (plant protection, etc.) and seed specialists (agronomists) and staff of the seed quality assurance agency consulting with breeders .
- 10% for building capacity of specialists of cereal seed production farms, including organizing training seminars and preparing training manuals.

3.2.6 Major achievements

From 1991-2018, there were only 16 applications for wheat on breeding achievements and all of them were issued certificates for plant variety protection. During 1998-2020, the SVTC received 34 applications and granted protection for one winter wheat and rejected six. The remaining 27 applications are still being tested (Table 4). In total, about 80 bread and 10 durum wheat varieties were tested for plant variety protection, with 53 granted protection (Table 3.2 and Annex 4). Among bread wheat varieties granted protection, five are from the domestic private sector. All applications were from domestic public agricultural research institutes except nine varieties from Krasnodar Research Institute of Agriculture in Russia and one from a private company in Turkey.

[9] *The research institutes (variety originators) will distribute the money among the authors (breeders) using form 296 where the share of each co-author is identified. Breeders could get their honorarium if a variety is registered in national catalogue and received the authorship certificate for the variety*

Table 3.2. Application for granting protection for wheat varieties (1998-2020)

Crop and originator	Country	# of applications	# of granted varieties	# of rejected varieties	# of varieties under testing	# of expired grants
Bread Wheat						
Samarkand Veterinary Medicine Institute	Uzbekistan	4	4	0	0	0
Tashkent State Agrarian University	Uzbekistan	1	1	0	0	0
RICLC	Uzbekistan	15	15	0	0	0
RICLC (Gallyaral Research Station)	Uzbekistan	12	5	0	0	7
RICLC (Qashqadarya Branch)	Uzbekistan	15	9	0	6	0
RICLC (Tashkent Branch)	Uzbekistan	1	1	0	0	0
RICLC (Karakalpak Branch)	Uzbekistan	2	2	0	0	0
Karakalpak Research Institute of Crop Husbandry	Uzbekistan	2	0	0	2	0
Research Institute of Genetics and Experimental Biology	Uzbekistan	6	3	2	1	0
Cotton Breeding, Seed Production & Agrotechnologies Research Institute (Surkhandarya Branch)	Uzbekistan	1	1	0	0	0
Research Institute for Plant Industry	Uzbekistan	3	0	3	0	0
Dilorom Yormatova	Uzbekistan	1	1	0	0	0
To'raqul Khojakulov	Uzbekistan	1	1	0	0	0
Kamil Artikov	Uzbekistan	1	1	0	0	0
Ollomurat Jumamuratov	Uzbekistan	1	1	0	0	0
Bo'zsuv Farm Association	Uzbekistan	1	1	0	0	0
KRIA	Russia	12	0	0	12	0
Private sector	Turkey	1	0		1	
Subtotal	**80**	**46**	**5**	**22**	**7**	
Durum Wheat						
Samarkand Institute of Veterinary Medicine	Uzbekistan	1	1	0	0	0
RICLC	Uzbekistan	1	1	0	0	0
RICLC (Qashqadarya Branch)	Uzbekistan	5	3	0	0	2
RICLC (Gallyaral Research Station)	Uzbekistan	2	2	0	0	0
KRIA	Russia	1	0	0	0	1
Subtotal	**10**	**7**	**0**	**0**	**3**	
Total		**90**	**53**	**5**	**22**	**10**

Note: RICLC= Research Institute of Cereal and Legume Crops; KRIA = Krasnodar Research Institute of Agriculture

3.2.7 Key challenges

Plant variety protection encourages plant breeders and seed companies to protect proprietary varieties from unlawful use, without infringing the rights of farmers using their own traditional or previously released varieties. Being in different ministries, the scope, roles, and responsibilities of SVTC and SIPA lack clarity. SVTC is authorized to maintain the national catalogue for all released protected and non-protected varieties, while SIPA maintains a list of protected varieties. This means plant variety protection is ineffective as neither STVC nor SIPA is adequately enforcing the breeding achievements in the country. SIPA is authorized to enforce variety protection under the Law on Breeding Achievements. However, SIPA neither conducts DUS testing, nor effectively enforces rights protected under the patent (patent, certificate, and license). SIPA has no resources, expertise and staff to monitor the seed market to prevent unauthorized seed sales and enforce rights. If a patent rights violation occurs, staff have no authority to enforce or sanction penalties.

The law on breeding achievements contains several provisions which do not conform to the UPOV Convention:

- The scope of the national law includes animal breeds, while the UPOV Convention covers only plant varieties
- Most definitions of the national law do not correspond to the UPOV Convention
- It uses IPR concepts such as patents and license agreements that should be substituted by a UPOV-based system of priority rights and notification.

The plant variety protection law needs to align with the UPOV Convention to conform with international norms and standards.

The Law on Breeding Achievements provides overall direction for private sector participation in the agricultural sector, particularly promoting investment in plant breeding – though it requires revising and effective implementation.

- Despite the law, national breeders (authors of varieties) do not derive full royalty income from the use of their varieties, even if granted a certificate from STVC and/or patent certificate from SIPA. As a result of an inefficient financial transfer system, the research institutes (originators of varieties) transfer money to the wheat breeders after long delays – constraining breeders to take advantage of the law's provisions.
- The Joint Stock Company (Uzdonmakhsulot) is responsible for collecting and transferring the honoraria to the Seed Development Center, which transfers the money to the agricultural research institute. Previously this is transferred to the special account of the Research Institute of Cereals and Legume Crops which distributes it to breeders, research centers, and seed producers (personal communication, 2021) delaying the disbursements.
- If a patent holder's rights are violated, the main legal recourse is to refer legal proceedings to the court, which is a general IPR (patent) enforcement provision. However, court hearings are lengthy and costly and there are no courts

specializing in disputes arising out of patent infringement.

- In Uzbekistan, the current practice of intellectual property protection tries to apply industrial inventions to plant variety protection, where the concepts of patents, trademarks, etc. may not equally apply in practical terms. The general consensus questions SIPA's involvement in PVP, because a new variety is not an invention per se. Delineating these issues are important for effective PVP implementation.
- Fragmenting PVP functions between SIPA and SVTC makes enforcement ineffective, as there is no clarity on which agency is to take enforcement measures, which should be part of the PVP inspectors' powers. It's advisable to define enforcement measures and powers and authorize one entity or institution with their enforcement.

3.2.8 Lessons learned

Current plant variety protection for cotton and wheat has proved to be a potential incentive for plant breeders to develop improved varieties. This may encourage private plant breeding and seed companies to invest in the seed sector. Therefore, it is important enforcement provisions are included in national legislation, adequate resources allocated, and expertise assigned to an authorized agency, responsible for protection of breeders' rights. It is recommended that plant variety protection is extended to new varieties of crops other than wheat and cotton.

3.2.9 Recommendations

Under the Law on Breeding Achievements, formulating PVP policy is assigned to SIPA. Legal protection implies enforcement of IPR rights, but IPR legislation instruments are not applicable to breeder's rights protection. It would be useful to consult and reach a consensus on the role of SIPA in implementing PVP. It would also be advisable to identify and designate an entity that is capable of examining varieties, maintain the national catalogue for new varieties of agricultural crops, and ensure effective enforcement. This will streamline the variety registration, ensure PVP enforcement competencies in one authority (MoA), and avoid duplication of efforts with SIPA which operates under MoJ. Moreover, there is talk among specialists and policy makers of establishing a fee for examination of plant variety protection.

Uzbekistan is a member of UPOV and signatory to the 1991 Convention, which primarily focuses on breeders' rights. However, focusing on uniformity and stability in protecting main non-food crops like cotton is restrictive and does not consider protecting farmers' rights and traditional varieties. It also threatens local biodiversity. It would be useful to consider joining the International Treaty on Plant Genetic Resources for Food and Agriculture, which would protect and promote farmers' rights, as they are the main custodians of traditional famers' varieties and conserve genetic resources.

To prepare for the new draft law on plant variety protection, amending the Law on Breeding Achievements is highly recommended to aligin it with the UPOV Convention.

This may incentivise both public and private sector investments in plant breeding and variety development. Particularly, the Uzbek law uses IPR concepts such as patents and license agreements inconsistent with the UPOV-based system. Therefore, it would benefit Uzbekistan to substitute those terms with a UPOV-based system of priority rights and notification. The plant variety protection law also requires revising to align with the UPOV Convention and conform with international norms and standards.

CHAPTER IV

Seed Production and Commercialization

Aziz Nurbekov, Abdoul Aziz Niane, Yigezu Atnafe Yigezu, and Zewdie Bishaw

4.1 Seed production

The Government of Uzbekistan recognizes the paramount importance of agriculture in national food security, increasing exports and improving the population's welfare. Supporting sustainable agriculture in a framework of emerging market models is a priority area to strengthen the economy and ensure social stability. Seed production plays a key role in providing farmers with quality seed from high-yield crop varieties, and contributes to maintaining domestic food security.

4.1.1 Introduction with historical context

Before independence, cotton was the major focus of seed production. An organized and coordinated wheat seed production started after independence in view of Government policy for food security and agricultural development. It's evident the national wheat seed sector involves both public and private farms in breeder, foundation, and certified seed production. The public sector, research institutes, and state seed farms are currently involved in seed production and marketing. While the private seed companies do not produce seed for cotton, they do for other crops including wheat and horticultural crops.

Since 1991, significant changes have taken place to organize seed production and modernize and transform the national seed sector. By diversifying the agriculture sector, the previous centralized seed production and control systems have been reformed where large-scale operation by the agricultural research was reduced gradually, particularly in seed production, storage, and seed quality control.

In 1996, the agricultural development policy – Cabinet of Ministers Resolution #157 – (September 12, 1996 https://lex.uz/) was adopted to achieve food security and economic development. The policy enabled a rapid increase in wheat production, particularly in developing and adopting modern wheat varieties. Since independence, wheat's become the second most important crop after cotton, and is widely grown across the country.

The Government is currently reviewing the previous policy developed over decades, particularly the five strategic priorities during 2017-2020 that focused on diversifying and intensifying agricultural production and expanding agricultural exports. The policy of gradually reducing the area of cotton in the country was started even earlier, along with an increase in the area for horticulture, forage, and oil crops.

4.1.2 Regulatory frameworks

An appropriate seed law and regulation should provide the foundation for establishing domestic seed companies and seed quality standards and procedures for producing and marketing seeds. A strong variety development and release system should encourage both national and foreign regional seed companies to develop new varieties that will compete with those currently available from Russia and the public sector, boosting domestic seed production.

The following key legislations are relevant for seed production (https://lex.uz/):

- The Seed Law #267-I (August 29, 1996) was a basic national law. It was amended by Law #252-I (April 25, 1997) and Law #772-I (Chapter XV – April 15, 1999) and #521 (February 16, 2019), which governs seed production and commercialization. It's aimed at conserving and using valuable domestic and international genetic resources effectively; developing a plant breeding program, developing high-yielding varieties adapted to different agro-climatic regions; and providing high-quality seeds to the agriculture sector through state control of seed production and quality.
- Resolution of the Cabinet of Ministers on an Uzbek Grain Production Joint Stock Company ("Uzdonmakhsulot") #376 (August 6, 2004), which defines relations between seed producers and public trade companies, granting exclusive rights for processing and exports of agricultural produce. Pursuant to existing regulations, seed producers are obliged to deliver seed produced to the Uzdonmakhsulot for seed processing, storage, marketing, and distribution.
- Resolution #13 (July 22, 2015) adopted by the Ministries of Agriculture, Finance and Economy set a premium price for wheat seed to encourage and engage seed farms in wheat seed production.
- Presidential Resolution to support domestic exporters and to enhance foreign economic activity (#258 (June 21, 2017) clearly demonstrates a policy shift to integrate the country's agricultural sector into the global economy. It intends to formulate legislation and procedures compliant with international plant quarantine standards, develop infrastructure (quarantine, laboratories), and implement legislative and institutional reforms involving the private sector in agricultural production and trade. It also removes restriction for farmers to sell their products at fixed prices exclusively to Government marketing enterprises. The resolution entitles farmers to export vegetables, fruits, grapes, and lemons directly at market prices.
- State Standards: mandatory state standards and technical conditions for seed certification schemes (methods, seed categories). Currently, there are over 140 state standards for seed production and seed quality control (registration, certification, methods) prepared jointly by specialists from the Department for Control of Agricultural Crops Seed Production, Seed Development Center, and state standards agency.

4.1.3 Institutional arrangements

The MoA and its affiliated departments are the main authorized organizations responsible for wheat seed production in the country. The wheat seed sector became centralized through Government involvement and direct participation of agricultural research institutions, Uzdonmakhsulot Joint Stock Company, and private farms as contract growers. The MoA must register all seed producers. Approval to produce certified seed is granted once the SDC is satisfied that seed farms have suitable land, equipment, and expertise to enable them to produce elite and certified seeds.

The Seed Development Center

The Seed Development Center (SDC) under the Ministry of Agriculture was formed from the merger of the Cotton and Cereal Seed Production Center and the Vegetable Seed Production Association. The SDC has three main departments: Cotton Department, Cereal Department and Vegetable Department each with provincial and district branches across the country.

The SDC is responsible for formulating policies and guidelines to develop national seed system (see Figure 1.1). It coordinates with Government officials at national, district and local levels to determine targets for seed production and then ensures targets are met by working with the agricultural research institutes, GPD and the Department for Quality Control of Agricultural Crops Seed Production (DQCACSP) of the State Inspectorate of Agro-industrial Complex (SIAC).

Currently, SDC coordinates cotton and cereal seeds as well as vegetables, melons and other crops for domestic and export markets. The Government organized seed clusters under SDC, based on public-private partnerships, to improve seed production in the country. Under these arrangements, seed clusters sell their seed to the Uzbek Grain Joint Stock Company, which processes and sells seed to farmers.

Uzbek Scientific Production Center for Agriculture and Food Supply

The Uzbek Scientific Production Center for Agriculture and Food Supply (USPCAFS) is part of the Ministry of Agriculture and administers 13 agricultural research institutes and public elite seed production farms, which are responsible for variety maintenance and early generation seed production (breeder and foundation seed). Foundation seed from the research institutes is provided to both public and private elite seed farms for further multiplication to certified seed, which operates under the umbrella of the Grain Production Department of the MoA.

Grain Production Department

The Grain Production Department (GPD) of the MoA has overall responsibility for certified seed (R1, R2 and R3) production of wheat, barley, triticale, and hybrids in the country. GPD has 13 regional branch offices for certified seed production. Potential seed growers (public or private elite seed farms) apply to the MoA to produce certified seed. The application ensures farmers have the land, irrigation, facilities, and experience to produce quality seed. It also stipulates the requirements of designated fields used to produce the seed crop. If an application is accepted, seed producers are given foundation seed from one of the regional research institutes. The farms receive a premium price on the raw certified seed produced.

Private seed companies

Although their share in total certified wheat seed supply is small, there are few domestic private seed companies operating in Uzbekistan. These private seed companies can produce seed of both public and private wheat varieties released in the country. They

can produce, process and market the wheat seed without going through the state quota system. Some foreign seed companies may import wheat seed and directly market to farmers based on demand.

4.1.4 Technical procedures

Wheat seed production is based on a generation system and produced by different organizations. These include public agricultural research institutes, foundation seed farms, elite seed production farms belonging to the Government, and private farms. The agricultural research institutes are responsible for producing early generation seed like super elite (breeder) and elite (foundation) seed, whereas the later generations of certified seed (R1, R2 and R3) are produced by public elite seed farms and on contract with the private elite seed farms who sell seed to Uzdonmakhsulot. All private seed grower farmers must sell their seeds only to Uzdonmakhsulot (Joint Stock Company), based on a contract between the elite seed farms and the company. Uzdonmakhsulot processes the seed and sells it to grain producer farmers. This is Government policy and aims to provide quality seed of new varieties to crop producers at preferential prices in a timely way.

Technical seed production practices (cropping history, isolation, rouging) are prescribed by the national field standards and crops inspected by the certification agency to ensure the varietal purity and any other factors affecting seed quality.

Seed production planning

To effectively plan seed production, accurate and detailed information on estimated seed use and demand is very important. The Government should organize timely collection and sharing of information to help both seed suppliers and seed consumers make appropriate decisions. The Government should also support and promote an administrative and information management system, for use by seed producers to plan seed production.

Seed categories for production

In Uzbekistan, wheat seed production follows an elaborate system including varietal purification and maintenance (nucleus seed 1 and 2), early generation seed production (breeder and foundation), and certified seed (R1, R2 and R3 (used in rare cases) production.

Variety purification and bulking: the wheat seed production scheme is very long and complex where both breeding and seed multiplication goes hand-in-hand from the early stages of purification of promising lines starting at competitive yield trials (see Figure 2.1) as follows:

- Ear (spike) to row (first year): about 2000-3000 ears of promising lines are selected and planted in single-ear rows and observed and recorded during the entire plant growth period, including disease resistance followed by mass selection by breeders from NARS or private companies.

- Row to plot (second year): selected materials and bulked from the first year are planted in a 10m2 plot and evaluated for disease reaction and mass selection by breeders from NARS or private companies.
- Nucleus seed 1 (first year): planting representing farmers conditions and evaluation continued for disease reaction and mass selection by NARS or private seed companies.
- Nucleus seed 2 (second year): follows the same procedure as the first year and is undertaken at the experimental farm of agricultural research institute or private seed companies.

When submitting a variety to SVTC, a breeder should have at least two tons of seed of the variety. This is to provide seeds of the candidate variety for testing in different agroecological zones of the country, while simultaneously starting early generation seed production of the variety at the agricultural research institutes.

Early generation seed: early generation seed production is carried out by agricultural research institutes and constitutes the following:

- Nucleus seed: produced by the breeder at a research station in small quantities as a parental material. This is passed to experimental farms of agricultural research institutes for further multiplication.
- Super elite seed (Breeder seed): produced by experimental farms of agricultural research institutes, elite farms, or private seed farms.
- Elite seed (Foundation seed): is a progeny of super elite (breeder) seed produced by elite seed farms or private seed companies.

The Research Institute of Cereal and Legume Crops (RICLC) and its branches in each province and the respective agricultural research stations are responsible for producing early generation seed. All agricultural research institutes have seed processing and storage facilities for cleaning breeder and foundation seed.

Certified seed: the Grain Production Department under MoA plays a key role in certified seed production. Large-scale commercial certified seed production is based on contractual agreement and is as follows:

- Reproduction seed 1 (Certified seed 1): is a progeny of super elite produced by public elite seed farms.
- Reproduction seed 2 (Certified seed 2): is a progeny of certified seed 1 produced by private elite seed farms.
- Reproduction seed 3 (Certified seed 3): is a progeny of certified seed 2 and currently this category is rarely produced.

Seed production arrangements

The Seed Development Center was established in 2018 to coordinate seed production at provincial and district levels in collaboration with the Department for Control of Seed Production of Agricultural Crops (DCSPAC) of the Inspectorate of Agro-

industrial Complex. They work with Government officials at provincial and district levels to determine the seed of crop varieties required for the coming season.

In each province, the SDC works with local officials at district and local levels to determine the targets for seed production are met. It also works with the DCSPAC of State Inspectorate of Agro-industrial Complex to ensure seed quality assurance services are provided to meet overall national targets.

Early generation seed (EGS) production: EGS (nucleus, breeder and foundation) production requires careful planning over several generations and careful technical supervision and inspection to ensure the quality of seed produced. The owner of the variety, public research institute or private seed company, is responsible for variety maintenance and EGS seed production. This is normally carried out by plant breeders at the agricultural research institutes. However, breeder seed production is carried out on many small fields over large areas, so supervising and coordinating is challenging. Foundation seed production is usually carried out by elite seed farms and rarely on contract with farmer seed growers.

The Government has regional seed processing facilities across the country to reduce transportation costs. All agricultural research institutes and stations have processing and storage facilities for EGS, where it's cleaned by the respective agricultural research institutes/stations. There are 14 seed processing plants, with a total capacity of more than 5,900 tons, located in agricultural research centers and with private seed companies.

Certified seed production: The Grain Production Department (GPD) has overall responsibility for certified seed production of wheat, barley, triticale, and hybrid seed in the country through 13 regional branch offices. Certified seed is produced on contract by farmer seed growers under DCACP supervision to maintain quality. Each seed grower farmer applies for certified seed production, and the lack of dedicated seed growers is always evident. Contract seed growers usually apply to the MoA to produce certified seed (rarely for foundation seed). The application ensures farmers have the land, irrigation, facilities, and experience to produce quality seed and meet the land requirements for cropping history and isolation distance. If the application is accepted, they're given foundation seed from one of the regional institutes to produce certified seed. They'll also receive a premium price on the certified seed they produce and deliver.

4.2 Seed commercialization

4.2.1 Introduction with historical context

Historically, agricultural production, processing, and marketing is under a centrally planned command economy, certain features of which persist. The Government procurement system still operates for major crops such as wheat and cotton, where farmers sell their produce to the Government through a quota system. To date, the same arrangement extends to seed production, processing and marketing. All wheat seed would

be produced under the Government contract and purchased by the Grain Production Company (Uzdonmakhsulot Joint Stock Company), responsible for processing, marketing, and distribution with no private sector involvement.

4.2.2 Regulatory frameworks

In Uzbekistan, there is a Government contractual agricultural production system (e.g. wheat is entirely under "state quota"). It's regulated by the Civil Code Articles 465-66 (Contracting/Procuring for the Government and Obligations of Producers of Agricultural Products/Farmers) (https://lex.uz/). This provision obliges farmers (including agricultural research institutes) to sell their produce (at a low price set by the Ministry of Finance[10]) to the "Agricultural Products Processing Enterprises". These are all Government-controlled enterprises (such as joint stock companies, holding companies, or agencies, etc.).

Resolution of the Cabinet of Ministers on an Uzbek Grain Production Joint Stock Company (Uzdonmakhsulot) #376 (August 6, 2004 – https://lex.uz/) represents the existing regulation defining relations between seed producer and state trading companies, which grants exclusive rights for export and processing of agricultural produces. Pursuant to the existing regulations, seed producers are obliged to sell their product to Uzdonmakhsulot for further processing and marketing. Regulations for procurement, storage and distribution of seeds is as stipulated by the register of the Ministry of Justice #935 (June 20, 2000 – https://lex.uz/).

4.2.3 Institutional arrangements

Under the Cabinet of Ministers, the Grain Production Company (Uzdonmakhsulot Joint Stock Company) is responsible for receiving, conditioning, storing, marketing, and distributing certified seed to farmers across the country. The GPC has 13 regional offices, each with seed processing and storage facilities, at strategic sites across the country.

Procurement and quota system

In Uzbekistan, wheat production is entirely under the contractual agricultural production and "state quota" system. Farmers sell their produce at price set by the Ministry of Finance to the "Agricultural Products Processing Enterprises", which are all Government-controlled enterprises (such as joint stock companies, holding companies or agencies, etc.).

Seed processing, storage, and distribution

The GPC (Uzdonmakhsulot) has 13 regional offices, each with seed processing and storage facilities, at strategic sites across the country based on the quantity of seed produced in each region. In total, there are 67 seed processing plants with a total annual capacity of 645,480 tons, processing 270,000 to 305,000 tons of seeds annually

[10] *Product purchase prices are approved annually by a special resolution of the Ministry of Finance*

representing utilization rate of 42-47% of available capacity (Annex 5). The total seed storage capacity is about 515,144 tons (Annex 5). Seed processing and storage is handled in the same facilities where food grain from these crops is processed and stored. This practice does not reflect the norms of seed production and may lead to mixing of seeds with grain products, which may compromise the final seed quality.

Seed marketing and promotion

Currently, there is no seed marketing because both production and distribution are centrally planned, although the supply and demand of seeds do not match. In practice, there's overproduction of seeds of one variety, and a deficit for another variety. There's no mechanism for marketing and commercializing new varieties, and it depends entirely on the skills of the breeder to promote their variety.

Seed pricing

Wheat and cotton seed prices are set by the Ministry of Finance, while for other agricultural crops, prices depend on supply and demand. State trade enterprises, like Uzdonmakhsulot with exclusive powers, are authorized to process, market, and distribute wheat seed and grain. Resolution #13 (July 22, 2015 – https://lex.uz/) adopted by the Ministries of Agriculture, Finance and Economy set a premium price for wheat seed to encourage and engage seed farms in wheat seed production. Accordingly, certified seed is 65% higher than the regular grain price while foundation seed and breeder seed prices are 100% and 200% higher than grain prices respectively (Figure 4.1). These incentives encourage many farms to apply for licenses for wheat seed production.

The agricultural bank provides credit with low interest rates to farmers. Credit is available for contract growers to encourage contract seed production. However, credit is not available for the purchase of certified seed because the Government is already subsidizing seed production.

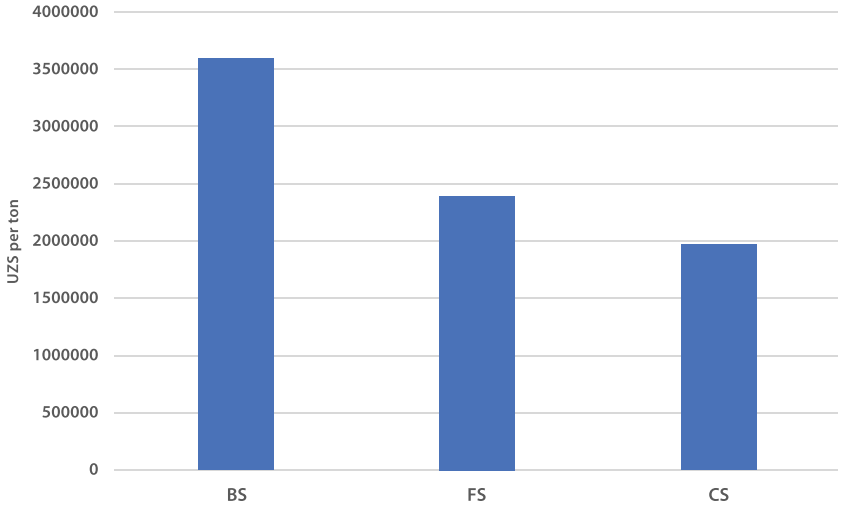

Figure 4.1. Wheat seed prices for different seed classes in Uzbekistan (2018) [11]

Note: BS = Breeder seed; FS = Foundation seed; CS = Certified seed.

4.2.4 Seed import and export

In Uzbekistan, seeds produced, imported, exported, or transited are subject to obligatory phytosanitary and veterinary control. The State Quarantine Department issues phytosanitary certificates for seeds exported, imported, or transited in Uzbekistan. The Government grants permission to import seeds required for research purposes, provided imports comply with relevant legislation. The Government also allows seed exports, but only after national domestic needs have been satisfied.

Import

In Uzbekistan, it is prohibited to import seeds, plants, and plant products containing dangerous pests, plant diseases and weeds. This includes all kinds of living funguses, bacteria and viruses causing plant diseases. It also includes plant-damaging insects and nematodes, except for samples imported for scientific purposes.

Importing seeds, plants, and products of plant origin is allowed if there is (a) an import quarantine permit issued by the State Inspection; and (b) a phytosanitary certificate issued by the National Plant Protection Organization (NPPO) of the exporting country. Imports from foreign countries where the NPPO does not exist are allowed on an ad hoc basis if Uzbekistan issues an import permit for quarantine.

Seeds, plants, or plant products exported from the territories under quarantine, without a phytosanitary certificate, can be seized. They can be transferred to storage organizations for technical (industrial) processing for use in public catering enterprises,

[11] *Source: MoA 2018 (personal communication)*

decontaminated, returned to sender, or disposed of.

Where the inspector has strong evidence there's a regulated pest or a pest of national concern in an imported consignment, they may prescribe treatment and disinfection. The importer bears all costs of phytosanitary measures, including treatment and disinfection, labor, transport, storage, and auxiliary materials.

Export

Export of regulated products from Uzbekistan requires a phytosanitary certificate issued by the State Inspection in accordance with phytosanitary requirements of the importing country. Quarantine law requires any person or legal entity exporting plants or plant products to apply to the State Inspection no later than 30 days before the expected shipment date, to identify the place of shipment. The same law requires any person to present consignments for export to the State Inspection for final control 15 days before shipment.

Goods in transit through Uzbekistan that contain seeds, plants and plant products are subject to mandatory examination under the Law on Plant Protection.

The Department for Control of Agricultural Crop Seed Production (DCACSP) under SIAC is funded from the national budget but emergency funds are collected from the fees charged for State Inspection services for such purposes. The law does not include offenses and penalties for breaching regulations.

4.2.5 Major achievements

In Uzbekistan, the wheat seed system is, at best, characterized by centralized planning and decentralized production. The Government organized a network of seed production and processing facilities throughout the country. Each province is producing its wheat seed requirement based on a national production plan and has seed processing facilities in 44 districts to reduce transportation costs. In Uzbekistan, seed production and certification consists of three major categories: breeder, foundation, and certified seed (Reproduction 1, Reproduction 2 and sometimes Reproduction 3).

The agricultural research institutes or universities (breeders or owners of a variety) are responsible for variety maintenance and breeder seed production. The Government allocates quotas of breeder seed to each elite seed farm under the MoA to produce foundation seed. The elite seed farms provide elite (foundation) seed to contract seed growers for further multiplication to certified seed (R1 and R2). This is under the supervision and overall responsibility of the Grain Production Department. The number of farms involved in contractual seed production varies from 3,397 to 4,545 farms, with an estimated area of 86,156 to 117,320 ha (Table 4.1). Farmers produce wheat seed under contract with Grain Production Company ("Uzdonmakhsulot"), but any excess seed produced under the contract can only be sold to the Government at a relatively higher price.

Table 4.1. Number of farms, area planted and wheat seed production (2010-2018)[12]

Year	Total seed production				
	Number of seed farms	Area planted (ha)	Yield (t/ha)	Gross seed production (t)*	Clean seed production (t)**
2010	4430	99,985	5.25	524680	297649
2011	4552	117,320	4.29	503265	304517
2012	3397	106,540	4.28	456238	308841
2013	3875	103,278	5.35	552083	304461
2014	3965	105,084	5.30	556586	302603
2015	3904	91,741	5.24	480784	293906
2016	4545	88,279	6.25	552154	344215
2017	4241	86,156	5.51	474889	297529
2018	3851	92,957	5.25	487760	295193
Average	**4041**	**99038**	**5.19**	**509827**	**305435**

*Note: *Raw seed and **clean seed produced under contract with Uzdonmakhsulot; and any excess seed produced will be sold at slightly higher price to Uzdonmakhsulot*

The certified seed produced is processed and provided to private farms for commercial grain production by the Joint Stock Company. In total, there are 49 seed processing plants in 67 strategic location across 13 provinces, with a total annual capacity of 315,000 tons. They process from 270,000 to 305,000 tons of seeds annually (Table 4.2) and have a total storage capacity of about 500,000 tons.

In 2016, the share of Russian bread wheat varieties decreased to cover 60% of the total wheat area in the country, while the share of domestic varieties increased to 40%. In 2018, about 281,944 tons of 42 bread wheat varieties and 8066 tons of seven durum wheat varieties were produced for irrigated and rainfed areas, respectively covering 1,089,480 ha and 40,800 ha in the same order (Table 4.3). The details of wheat seed production and area coverage shows availability of very diverse varieties on the seed market. It is anticipated that certified seed covers all wheat area cultivated by large farms- a seed replacement rate of 100% (excluding small farms). This is very high by many other countries' standards. In Turkey, for example, the target for national seed replacement rate is aimed at 33%- replacing certified seed of wheat every three years (Bishaw et al. 2021).

The variety called Grom (released in 2013) makes up about 14.9% of certified wheat seed production and covers about 14.7% of wheat area, followed by Krasnodar 99 (2008), Asr, and Tanya (2010), Gozgan (2018), and Vassa (2016). Table 4.3 provides data on the area devoted and amount of certified seed produced. The top five bread wheat varieties make up about 45.1% of certified seed production and 44.6% of area coverage. This is relatively diverse, with the number of varieties in seed production unlike many countries where very few mega wheat varieties dominate the wheat production landscape.

[12] *Source: MoA 2018 (personal communication)*

Table 4.2. Wheat seed production (tons) for irrigated and rainfed areas (1991-2018)

Seed category	1991	1995	2005	2016	2018
Breeder seed	223	2,204	5,690	5,351	5,450
Basic seed	3,540	22,045	45,560	18,800	20,542
Certified seed	20,850	186,729	218,750	282,000	269,210

Source: MoA

Table 4.3. Wheat seed production and distribution for irrigated and rainfed areas (2018)

	Variety	Certified seed produced (t)	% of certified seed produced	Area planted by certified seed (ha)	% of total area covered
	Irrigated				
1	Grom	43143	14.9	165936	14.7
2	Krasnodar-99	27624	9.5	106248	9.4
3	Asr	22937	7.9	88218	7.8
4	Tanya	21883	7.5	84165	7.4
5	Gozgon	15501	5.3	59619	5.3
6	Vassa	14672	5.1	56431	5.0
7	Yaksart	12020	4.1	46230	4.1
8	Chillaki	10331	3.6	39735	3.5
9	Starshina	9100	3.1	35000	3.1
10	Davr	7421	2.6	28542	2.5
11	Pervitsa	7088	2.4	27261	2.4
12	Zimnitsa	7071	2.4	27195	2.4
13	Bobir	6772	2.3	26047	2.3
14	Andijon-4	6378	2.2	24531	2.2
15	Andijon	5585	1.9	21480	1.9
16	Brigada	5323	1.8	20473	1.8
17	Jayhun	5074	1.7	19514	1.7
18	Yuka	4852	1.7	18662	1.7
19	Gratsiya	4688	1.6	18031	1.6
20	Kroshka	4070	1.4	15655	1.4
21	Tabor	3824	1.3	14706	1.3
22	Zvezda	3516	1.2	13524	1.2
23	Do'stlik	3381	1.2	13525	1.2
24	Jasmina	2973	1.0	11891	1.1
25	Durdona	2772	1.0	11086	1.0
26	Buyodkor	2076	0.7	8305	0.7
27	Esaul	1687	0.6	6748	0.6
28	Lebed	1452	0.5	5807	0.5
29	Sila	1358	0.5	5433	0.5
30	Turkiston	1125	0.4	4500	0.4
31	Vostorg	1023	0.4	4091	0.4
32	Bezostaya-100	697	0.2	2789	0.2
33	Semurg	649	0.2	2595	0.2
34	Hisorak	585	0.2	2339	0.2
35	Alekseevich	588	0.2	2351	0.2
36	Nota	62	0.0	246	0.0
37	Antonina	468	0.2	1871	0.2
38	Yogdu	349	0.1	1394	0.1
39	Gurt	122	0.0	489	0.0
40	Drujba	3	0.0	12	0.0
41	O'zbekiston-25	6	0.0	24	0.0
42	Yangi navlar	11695	4.0	46781	4.1
	Subtotal	**281944**	97.2	**1089480**	96.4
	Rainfed				
1	Surkhak-5688	672	0.2	3400	0.3
2	Hazrati bashir	1384	0.5	7000	0.6
3	Sanzar-6	771	0.3	3900	0.3
4	Tezpishar	1364	0.5	6900	0.6
5	Zamin	297	0.1	1500	0.1
6	Hisorak	1344	0.5	6800	0.6
7	other varieties	2234	0.8	11300	1.0
	Sub-total	**8066**	2.8	**40800**	3.6
	Total	**29,0010**	100	**1,130,280**	100

Source: MoA, 2018

Trends in certified seed production for wheat from 2011-2019 are shown in Figure 4.2. In view of few changes in total cultivated wheat area, there's little fluctuation in the quantity of seed produced both for irrigated and rainfed areas. On the other hand, the number of bread wheat varieties increased from 11 in 2011 to 37 in 2019, whereas

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those for rainfed remained constant around seven varieties. An important phenomenon observed over the years is the change in the mix of varieties, where some old varieties are dropped and replaced by new improved varieties.

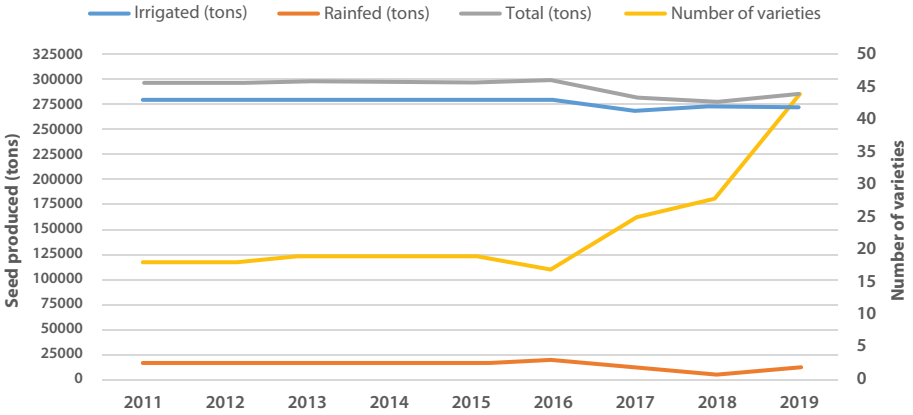

Figure 4.2. Trends in irrigated and rainfed certified seed production of wheat (2011-2019)[13]

Figure 4.3 shows the varietal composition of wheat seed production for irrigated areas from 2011-2019. The varieties Krasnador-99, Tanya, Moskovich, Kroshka and Chillaki remain dominant in terms of seed production over the years, although their share continues to decline. Since 2016, new improved varieties such as Grom, Asr, and Yaksart are increasingly replacing the old varieties regarding seed production. Yusa, Vassa and Gozgoan appear to be increasing from 2018 onwards. There's a clear shift in spatial and temporal diversity of seed production and wheat production as shown in Figure 4.3. According to Lantican et al. (2014), the weighted average age of wheat varieties in Uzbekistan was between 8-10 years. However, the survey data shows the weighted average age of wheat varieties in Uzbekistan was 6.6. Analysis of the trends in wheat seed production also shows good performance in the wheat seed sector.

[13] *Source: MoA 2020 (personal communication)*

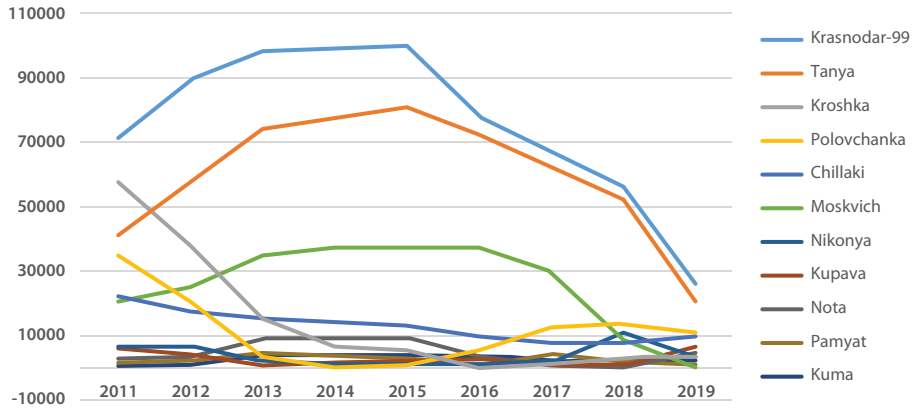

Figure 4.3. Trends in wheat seed production for irrigated areas[14]

Seed production, distribution and pricing remain centrally controlled, based on the Cabinet of Ministers' annual resolutions, which are implemented under a comprehensive seed production program. The MoA has overall responsibility for establishing a seed production plan and ensuring a certified seed supply to all commercial crop production farms.

4.3 Key challenges

Technical constraints

Government policy on seed production was first introduced in 1996, but it was never implemented due to major changes in the overall economic policy towards import substitution and the protectionist trade policy described earlier. Since 2015, there have been gradual changes in Government agricultural policy towards diversifying and intensifying agricultural crops, and reducing the cotton and grain monopoly and overall Government monopoly in trade over agricultural production. However, major challenges remain to modernizing the seed sector.

The Grain Production Joint Stock Company (Uzdonmakhsulot) is a Government agency with a monopoly on procurement, processing, and marketing of agricultural commodities of both seeds and grains through exclusive rights from variety owners. This arrangement enforces the Government monopoly, but without paying attention to the specifics of separately handling seed production and grain production. This leads to varietal and seed mixing and reduced seed quality. This hinders availability of varieties with specific quality traits and access to quality seed by farmers. Seed marketing is poorly regulated and there are no legal measures if marketing rules are violated.

The Seed Development Center and agricultural research institutions under MoA are mostly retained from the Soviet era and are not aligned with international norms and reference

[14] *Source: MoA 2020 (personal communication)*

standards such as ISTA's International Rules for Seed Testing and OECD seed certification schemes. They are technically outdated and do not address current challenges or needs of the agriculture sector in general, and the national seed system, in particular. The research infrastructure and seed production, processing and storage facilities are also antiquated and need replacing to ensure quality and timely operation. It's necessary to improve the material and technical resources of seed production and plant breeding institutions.

Since 2015, there have been gradual changes in agricultural policy to diversify the sector and limit the Government monopoly on trade in agricultural production. However, the newly adopted Decree #521 (February 16, 2019) makes the procedures for import and export even more cumbersome. The requirement for registration testing of foreign varieties, whose seed is imported, makes imports costly and lengthy and increases the risk of smuggling. Moreover, new requirements to obtain permission from the Cabinet of Ministers and the MoA for seed exports are unnecessary, excessive and it's unclear how they'll be issued. This hampers exports and contradicts the policy for export development of agro-products announced by the Presidency.

In general, it's expected that demand and supply should guide seed production. However, the Government sets target seed production whereas farmers can choose varieties. Although seed production is centralized and planned by Government, there's a mismatch between seed produced and demand for varieties farmers want. It's critical to consider farmers' choices and have reliable information about the seed market, including domestic production, the sale of seed in each region, and seed imports. This is essential for farmers to make more informed decisions. Wheat seed production must ensure high-quality seed is both available and accessible to all farmers in areas where varieties are adapted.

Currently, all wheat area cultivated by state and private farms (excluding dehkan and households) is covered by certified seed based on the Government's plan. This plan details where several varieties (42 bread and seven durum) are produced, processed, and distributed involving public organizations which could be inherently inefficient and bureaucratic (Table 5.1). The arrangement to produce and process the certified seed need in the country may put a huge and unnecessary burden on the physical, financial and human resources of the country – unless the benefits of this practice outweigh the costs. Seed experts recommend an average seed replacement rate for self pollinated crops such as wheat of 25% (i.e., for farmers to replace seed once every four years). Normally, apart from the capacity issues, such annual seed replacement may not be economically justified. Therefore, it would be useful to rationalize the scheme and introduce a reform to bring the current annual replacement rate down to acceptable levels.

Regulatory constraints

The new Seed Law #521 (February 16, 2019) on seed production and implementing regulations, lacks clarity. It should emphasize further liberalization to comply with market principles. The revision should consider:

- Access to modern technologies, knowledge and equipment.
- Access to finances to introduce new technologies (varieties, machinery, equipment).

- Access to infrastructure (logistic centers, storage facilities, machinery, transportation).
- Promoting private investments in the agriculture sector.
- Ensuring product quality and safety.
- Procuring quality inputs (seeds, fertilizers, agrochemicals).
- Pricing products produced through market forces.

In practice, the MoA and regional authorities formulate all recommended seed production policies, regulations, procedures, and measures. Together, they're responsible for providing agricultural inputs and products under Government procurement orders. Regional authorities submit their proposals to MoA, which in turn submits them to the Cabinet of Ministers for approval. This lengthy process diffuses responsibility among various entities, and hinders achieving the objective and timely provision of quality seed to seed producers and farmers.

4.4 Lessons learned

The Government is actively pursuing privatization of seed farms on two fronts: (i) transferring ownership of state and collective farms to joint stock companies to enter seed production and marketing; and (ii) developing private farms for commercial grain production. Qo'qon Seed Cluster, the first seed cluster, aims to improve seed production by privatizing public seed production in the country. The seed cluster includes seed growers, seed processors, and seed sellers, who previously worked independently in the existing production system. This initiative has started in five provinces and will be expanded to others in future years if the first seed cluster is successful.

When Government has a strong role in managing the seed market, it is important to examine its objectives, costs, and the benefits to farmers and society, and to think about whether its involvement should be phased out over time, and how. With the Government's major role in seed production and distribution of cereals (wheat) and cotton, it's difficult to think about changes until there's a well-developed and stronger role for the private sector.

4.5 Recommendations

The Uzbekistan seed sector has the potential to enter and increase its share in the wheat seed market in Central Asia. Efforts should be made to increase production of wheat seed and develop regionally competitive varieties. Harmonizing procedures with those at international and regional levels will be useful to tap into the regional and global seed industry effectively.

The new Seed Law #521 (February 16, 2019 – https://lex.uz/) needs revising to show the scope of regulation and specify the variety registration, seed production, processing, marketing, quality control, import and export. It's advisable the law applies equally to both local and imported seed intended for production and reproduction. As mentioned in the constraints section above, the new Seed Law on seed production and implementing regulations lacks clarity. It should further emphasize liberalization to

comply with market principles. The revision should consider:

- Access to modern technologies, knowledge and equipment.
- Access to finances to introduce new technologies (varieties, machinery, equipment).
- Access to infrastructure (logistic centers, storage facilities, machinery, transportation).
- Promoting private investments in the agriculture sector.
- Ensuring product quality and safety.
- Procuring quality inputs (seeds, fertilizers, agrochemicals).
- Allowing the market forces of demand and supply to determine product prices.

Appropriate knowledge and skills are necessary to use improved seeds and other modern agricultural technologies properly. It is essential to develop and implement extension, educational and training programs to enhance the transfer of modern seed production technologies to all seed sector stakeholders, including the private seed sector.

It is recommended continuing to increase productivity and production in the agriculture sector through an enabling environment that encourages innovation and support for farmers via access to:

- Quality seed of new varieties.
- Low-interest, affordable credit for inputs and machinery, from rural banks.
- Locally manufactured, lower-cost farm equipment like raised-bed planters and zero-till drills .
- Water-saving technologies such as sprinklers, drips, and plastic mulching of furrows in wheat or cotton to increase water-use efficiency and conserve scarce resources.

Currently, the Grain Production Joint Stock Company (“Uzdonmakhsulot”) is responsible for handling both seed and grain at the same facility. Lack of distinction between both operations and current practice don’t reflect typical seed production, which can lead to mixing of varieties and poorer quality seeds. It’s advisable to either separate the two operations or establish a separate entity for seed production.

There are different models for early generation seed production. In some countries, EGS enterprises or agencies are responsible for producing and commercializing seed. Uzbekistan needs to set up a system that ensures production of high-quality seed of the desired varieties each year in each province.

There’s no critical number of seed importers and seed companies to justify a national seed association to create a common platform to represent the interests of the seed industry, particularly the private sector. However, there may be an option to establish an association for seed growers that aims to improve the quality of seed produced, increase profitability, and support seed growers to develop and become fully fledged seed enterprises.

Chapter V

Seed Quality Assurance and Certification

Zewdie Bishaw, Aziz Nurbekov, Abdoul Aziz Niane, and Yigezu Atnafe Yigezu

5.1 Introduction with historical context

The seed quality assurance and certification scheme is a key part of the seed sector. It uses an array of conventional field inspection procedures and seed quality testing methods to maintain varietal purity and identity, physical purity, physiological quality, and health. However, quality assessment techniques continue to evolve with scientific advances, where seed quality enhancements practices such as pelleting, priming and pre-germination, require inspection of seed quality before and after the treatment process.

Previously, the State Seed Certification and Quality Control Center (SSCQCC), established in 1995 under the MoAWR, was a Government agency responsible for quality control and certification of agricultural crops in the country. Recently, a new agency called State Inspectorate of Agro-industrial Complex (SIAC) was established in 2019 to assume the responsibility. It is accountable to the Cabinet of Ministries to replace SSCQCC. SIAC has a Department for Control of Agricultural Crop Seed Production (DCACSP), responsible for seed quality assurance and certification of agricultural crops.

5.2 Regulatory frameworks

The Law on "Certification of Products and Services" #245 (December 28, 1993), together with the Law on "Standardization" #1006-12 (December 28, 1993 – amended April 25, 2003 provide governance for seed certification in Uzbekistan. Previously, the SSCQCC, established in 1995 under the MoAWR by the Resolution of the Cabinet of Ministers of Uzbekistan (https://lex.uz) #421 (October 31, 1995) was responsible for seed certification. SSCQCC's functions were set out by the Resolution of the Cabinet of Ministers #553 (December 18, 1997, Table 5.1).

Currently, responsibility for seed quality and certification lies with the Department for Control of Agricultural Crops Seed Production (DCACSP) of State Inspectorate for Agro-industrial Complex (SIAC) under the Cabinet of Ministries. DCACSP has the same function as the SSCQCC, as set out by the same Resolution and is accredited by the State Committee on Standardization, Metrology and Certification (Uzdavstandart).

Table 5.1. Seed certification processes, procedures, and methods in Uzbekistan

No	Standard	Purpose
1	GOST 20290-74	Agricultural seeds- Determination of sowing qualities
2	GOST 20081-74	Agricultural Seeds- Plant breeding process
3	GOST 12036-85	Agricultural seeds- Rules of procurement and sampling methods
4	GOST 12038-84	Agricultural seeds- Germination determination methods
5	GOST 12039-82	Agricultural seeds- Vaibility determination methods
6	GOST 12041-82	Agricultural seeds- Humidity determination methods
7	GOST 12042-80	Agricultural seeds- Weight determination methods
8	GOST 12043-88	Agricultural seeds- Originality determination methods
9	GOST 12044-81	Agricultural seeds- Contamination determination methods
10	GOST 12045-81	Agricultural seeds- Pest determination methods
11	GOST 12046-85	Agricultural seeds- Seed quality documentation
12	GOST 12047-85	Agricultural seeds- Seed quality determination.
13	PMG 36-2001	Rules for international standardization

Source: ICARDA (2005)

SSCQCC Order, PD-02-2003, is a standard document used by the DCACSP to certify seed (Table 5.1). The document, approved by the national certification agency (Uzdavsstandart), is part of the national seed certification scheme. It specifies detailed procedures for certifying agricultural seed and defines the ordinance of seed certification (except cotton seed). The ordinance is mandatory and used by the Department and its central seed testing laboratory, seed farms, seed producers, procurement centers, processing plants and seed users.

Seed certification should comply with standards as specified in regulations for agricultural crops including seed quality; seed sampling methods; seed testing for germination, viability, moisture, weight, purity, contamination, pest infestation; and documentation and rules for standardization. In Uzbekistan, all seed offered for sale has to meet field and seed standards set for seed quality control and certification in line with national seed and plant quarantine regulations.

5.3 Institutional arrangements

Uzgosstandart is the national certification agency for all products. Its main functions are to establish and develop general certification rules; enter international certification agreements; accredit certification agencies and laboratories; control and supervise certification; cancel and suspend certificates and labels; cancel accreditation certificates; and terminate activities of agencies for violating legal certification norms. Uzgosstandart can delegate part of its functions to similar product certification agencies and laboratories. Mandatory certification is required for testing a product to determine its characteristics pursuant to normative documents' requirements and state control and supervision of certified products.

According to the latest Seed Law #521 (February 16, 2019 – https://lex.uz/), the DCACSP (ex SSCQCS[15]) selects varieties and seed standards for planting, where the SIAC is a competent authority for seed certification[16]. The regulation sets out its

[15] *Regulation 1 of Resolution of Cabinet of Ministers #553 of December 1997*
[16] *Article 8 of Seed Law #521 February 16, 2019 requires certification mandatory for seed production and marketing*

functions, which include:

(i) Implementing seed production programs
(ii) Organizing examination of seed and establishments
(iii) Administering and organizing regional and district offices for seed quality control
(iv) Developing, improving, and approving seed quality test methods.

DCACSP has three main departments at its headquarters. These are the Certification of Seeds of Agricultural Crops (five staff), the Central Laboratory of Seed Quality (19 staff), and the Field Inspection Department (11 staff).

DCACSP also has 13 provincial offices (four staff each) and 122 district representative local offices for seed certification across the country. There are 125 inspectors based at the provincial and district offices for field inspection of both early generation and certified seeds for over 40 different agricultural crops.

The Government has also established and maintained one central seed laboratory and 12 regional seed testing laboratories that allow quick delivery and testing of seed samples. Each province has a regional laboratory for seed testing. Most districts have a local seed testing laboratory (122), where seed samples are tested according to state-approved procedures for seed quality control.

The central seed laboratory receives seed samples from 12 regions in the country. It monitors the quality of the tests conducted by provincial laboratories. Nearly 10,000 seed tests are conducted annually at the central seed laboratory for quality and reference testing.

5.4 Technical procedures

Certification Order PD-02-2003 is a standard document agreed with Uzdavstandart and used as part of the national seed certification scheme. The document sets out all the procedures for certifying agricultural seeds and defines the seed classes for certification (except for cotton seed). The document is mandatory and used by the inspectorate and its central seed testing laboratory, seed production farms, procurement centers, processing plants, and other seed producers and consumers. It complies with requirements of UZ 5.0 and UZ 51-62 of the Republican Standard of Uzbekistan.

Applying for certification

All seed producers make declarations and apply for seed certification to the Department for Control of Agricultural Crops Seed Production of State Inspectorate of Agro-industrial Complex. The application specifies the grower, location, crop, variety, area, seed class, and the company. In Uzbekistan, all seed production fields are subject to formal field inspection for all seed classes. This includes the nucleus, super elite (breeder), elite (foundation) and certified seed. Currently, on average, around 4000 farms are engaged in wheat seed production.

Field inspection

Nucleus and breeder seed fields are inspected by the breeder, while foundation seed fields are inspected by the breeder or their authorized representative. The latter should be trained by the breeder or attend special training courses and be well-acquainted with the morphological characteristics of the varieties. In the month of May each year, the Ministry of Agriculture adopts a decree to establish a wheat field inspection committee at national, provincial and district levels. Its members include representatives from MoA, SIAC, Seed Development Center, Uzbek Agriculture Chemical Protection Agency, Council of Farmers, small (dehkan) farms and owners of household land. This brings the total number of field inspectors from all institutions to 610. Certified seed fields are usually inspected by authorized inspectors of field inspection committee members at all levels.

A field inspection manual, developed in 1978, is still used (MoA, 1978). For bread wheat, generally, only one inspection is required. During field inspection, detailed information is checked as indicated in the application including location, variety, seed class (certification tag from seed lot or sack), isolation distance, and previous cropping. Varietal identity and purity must meet the standards. The minimum field size allowed for wheat seed production is 10 ha in irrigated areas and 20 ha in rainfed areas. Seed production fields should meet field standards for cropping history, isolation, varietal purity, other crops, noxious weeds, and seed-borne diseases. A field inspection is conducted during wheat's waxy maturity stage. Inspection is carried out on a representative sample area of at least 100m2. The off-type counts are then related to the population estimate to determine the crop's cultivar purity. At the end of each inspection, a report is written including the decision to approve or reject the field.

Seed testing

Seed production fields that meet field standards are harvested and transported to the Uzdonmakhsulot company's processing centers . Seeds are cleaned and kept in seed lots for sampling and storage. Seed sampling and testing is carried out according to the rules, procedures, and methods developed for each species by the national seed certification scheme. Laboratory seed testing includes physical and genetic purity, germination, seed moisture content, weight, germination and vigor.

Several provincial and district-level laboratories are not fully functional. The three seed testing laboratories accredited by the Uzbek Standard Agency which are also fairly functional are the Central Seed Laboratory, Khorezm seed testing laboratory, and Nukus seed testing laboratory. The central seed laboratory (CSL) is responsible for testing seed of agricultural crops, which represents about 80% of seed samples tested annually. It receives reference seed samples from all 12 regional seed testing laboratories. CSL is also testing reference samples including other quality tests for certification. Provincial seed laboratories collect 1 kg seed samples from a seed lot of up 60 tons and send them to the CSL. Other provincial and district laboratory only test some seed for quality – moisture, purity, thousand-kernel weight, etc. Only seed lots fulfilling both field and

seed standards can be certified and planted in state or private farms. Wheat represents approximately 45% of the seed samples tested annually.

Post-control plots

Post-control plots are planted with seed samples taken from seed lots certified in the previous season and in accordance with the OECD seed scheme. The main benefit of control plots is to ensure the certification system works well and that varietal characteristics remain the same during seed multiplication. For nucleus and breeder seed, 100% of the seed lots are represented. For certified seeds, 10-20% of seed lots are represented.

Seed certification

Certified seed should meet basic quality standards in relation to: analytical purity, weed seed, crop seed, inert matter, noxious weed seeds, and date of germination test. All certified seeds should also be labeled before marketing. The label should include the following information:

(i) Variety name and seed category
(ii) Year of production
(iii) Plot number
(iv) Analytical purity (%)
(v) Weed seed (%)
(vi) Crop seed (%)
(vii) Inert matter (%)
(viii) Name and number of restricted noxious weed seeds per kg
(ix) Date of germination test.

If the seed is treated, the label must: a) show the treatment, b) be labeled with a 'poison' symbol, and c) include the name and address of the person who labeledthe seed, sold, or offered it for sale.

5.5 Major achievements

For both field inspection and laboratory testing, the seed certification scheme guarantees the quality of the seed available on the market based on laws, regulation, and procedures adopted in the country and aligned to international rules and norms. The Government provided information and awareness about seed quality and certification schemes where it was of concern to all seed sector stakeholders. To provide an effective seed quality assurance, each seed producer maintains its own internal quality control.

Currently, there are 150 inspectors based at the provincial and district offices for field inspection of both early generation and certified seeds for over 40 different agricultural crops. The central seed laboratory is well equipped to undertake a comprehensive seed testing program in the country with capacity of nearly 10,000 samples per year.

The area and number of farms engaged in wheat seed production remains steady though fluctuates year to year (see Table 4.3). On average, about 4,084 farmers (from 3,391 to 4,552) engaged in wheat seed production, planting an average of 99,038 ha (from 86,156 to 117,320 ha) annually. This led to an average gross wheat seed production of 509,827 (from 474,889 to 556,586) tons, with an average of 305,435 (range from to 293,906 to 344,215) tons under contract with Uzdonmakhsulot per annum.

Considering the average seed production figures above, there are an estimated 20,393 (ranging from 18,250 to 22,086) seed lots for gross production or 12,217 (ranging from 11,756 to 13,706) seed lots for seed produced on contract with Uzdonmakhsulot annually at the maximum seed lot of 60 tons for wheat seed.Table 5.1 shows the results of field inspection and laboratory analyses for bread wheat, for the 2010 to 2018 crop seasons. Over the last nine years, the seed production fields area ranged from 86,156 ha to 117,320 ha. The average seed production area was about 99,308 ha with an average rejection level of 6.1%, which is quite acceptable. The major cause for rejection was contamination with noxious weeds, with a few exceptions related to failing to adhere to cropping history or crop rotation. The amount of certified seed analyzed for the same period ranged from 293,906 tons to 344,215 tons. The average certified seed analyzed was 305,435, with an average rejection level of 8.7%, which is reasonable. The number of seed samples analyzed fluctuated from 9,760 to 11,473. The average number of samples analyzed was 10,180, with an average rejection rate of 5.95%, with major rejection reasons due to other crop seeds. The rejection of field inspections due to noxious weeds and seed quality analysis due to other crops though remains low. This shows the state of poor management of seed production fields and seed processing facilities.

Table 5.2. Wheat field inspection and laboratory analysis results (2010-2018)[17]

Crop season	No of fields	Area planted (ha)	Area approved (ha)	Area rejected (ha)	Proportion of area rejected (%)	Main reason for rejection	Quantity of seed analyzed (t)	Quantity of seed approved (t)	Quantity of seed rejected (t)	Proportion of seed rejected (%)	No of seed samples tested	Number of samples rejected	Proportion of samples rejected (%)	Reason for rejection
2010	4120	99985	96353	3632	3.63	Noxious weed	297649	277371	20278	6.81	9921	870	8.77	other crops
2011	4300	117320	111992	5328	4.54	Noxious weed	304517	286275	18242	5.99	10150	540	5.32	other crops
2012	4250	106540	95640	10900	10.23	No crop rotation	308841	282872	25969	8.41	10294	640	6.22	other crops
2013	4260	103278	100787	2491	2.41	Noxious weed	304461	270355	34106	11.20	10148	380	3.74	other crops
2014	4365	105084	97815	7269	6.92	Noxious weed	302603	274756	27847	9.20	10086	456	4.52	other crops
2015	4180	91741	82238	9503	10.36	Noxious weed	293906	287729	6177	2.10	9796	842	8.60	other crops
2016	4258	88279	85438	2841	3.22	Noxious weed	344215	288107	56108	16.30	11473	1120	9.76	other crops
2017	4528	86156	81406	4750	5.51	No crop rotation	297529	280216	17313	5.82	9917	359	3.62	other crops
2018	4452	92957	88234	4723	5.08	No crop rotation	295193	282054	13139	4.45	9839	247	2.51	other crops
Average	**4301**	**99038**	**93323**	**5715**	**6.12**		**305435**	**281082**	**24353**	**8.66**	**10180**	**606**	**5.95**	

[17] *Source: Seed Development Center 2019*

5.6 Key challenges

The seed certification scheme uses different seed classes, which are accepted nationally but don't conform to international nomenclatures. Uzbekistan has not yet achieved ISTA accreditation, despite several projects which concluded with remarks encouraging the Government to join ISTA. This situation will deter the movement of varieties and seeds such as the OECD seed schemes for varietal certification and seed testing laboratory accreditation by the International Seed Testing Association. As a result, the Uzbek seed sector cannot play a role in the regional or global seed industry, become a member, or be accredited by international seed-related organizations.

The national field and seed standards are high and difficult to achieve for most seed producers, leading to the rejection of large quantities of good-quality seed. There are problems with quality of certified seed due to varietal admixtures, poor physical quality (damaged or shriveled seed) or low germination. The present field inspection system for ensuring varietal purity appears quite cumbersome and requires a lot of work. These problems can be linked to:

(i) Incorrect seed sampling procedures and low capacity of technicians.
(ii) Obsolete and poorly maintained cleaning machines with damaged screens for proper seed cleaning.
(iii) Handling of raw seed together with food grain that could hinder the traceability of seed lots and the potential for the admixture of seed and grain during processing and storage.

Adopting feasible and acceptable standards in line with standards elsewhere, would help accelerate growth in the seed sector.

The central seed laboratory is well-equipped to undertake a comprehensive seed testing program in the country and received accreditation from Uzbek Standard Agency. The only provincial laboratories that are accredited are Khorezm and Karakapkastan. However, other provincial laboratories need a major overhaul of facilities and the capacity of staff to learn new methods, procedures, and guidelines for seed testing.

5.7 Lessons learned

The Ministry of Agriculture adopts a decree to establish a wheat field inspection committee at national, provincial and district levels annually, with members drawn from public institutions, civil societies, and private individuals for the timely operation of seasonal workload. Seed production fields are inspected by authorized inspectors from members of the field inspection committee at all levels. This could be an alternative approach to maintaining a huge workforce for very seasonal work such as field inspections. The efficiency and cost-effectiveness of this approach need evaluating.

The seed certification scheme has a well-equipped central laboratory with a capacity that can handle over 10,000 seed samples annually. Apart from seed testing of agricultural

crops, it also receives reference samples from regional provincial laboratories to monitor the quality of test results. This will help identify problems and take corrective measures to improve reliability and uniformity of seed quality assurance across the country.

In Uzbekistan, the seed certification scheme is centralized and operated by the public sector. All farmers across the country sow only certified wheat seeds under strict Government control. The Sate Inspectorate of Agro-industrial Complex became independent of MoA and placed under the supervision of the Cabinet of Ministries, streamlining its functions and powers to avoid potential for rent-seeking.

5.8 Recommendations

Coordination between the State Inspection for Plant Quarantine and the Department for Seed Import and Health Control of Agricultural Crops is required to enable and accelerate seed imports. It is important to avoid unnecessary delays in seed imports but also balance the need to guard against the introduction of harmful pests and diseases. The administrative procedures for seed import and export should be minimized to ensure only internationally recognized quarantine and seed testing requirements are observed. The relevant agencies will be required to provide all possible support to accelerate the procedures for shipping, customs clearance, currency exchange, issuing letters of credit, etc.

Aware of the need for rapid, reliable, and accurate seed quality testing in the seed sector, the Government should establish and maintain a network of adequately-equipped and staffed official seed testing laboratories in locations that allow quick delivery of staffed samples and rapid test results. All seed testing operations should be conducted according to the international rules for seed testing of ISTA. An effort should be made to undertake a quality audit to determine the source of problems and correct them so farmers have confidence in the certified seed market.

For seed quality assurance and certification, simple and reliable methods and procedures need to be adopted in line with other international norms and protocols. These include time frames, fees, and standards. Currently, the same old field inspection and seed testing manuals from FSR are used. A review of procedures and manuals, training programs to strengthen the capacity of the staff, and investment to strengthen the facilities for seed quality control and certification are needed.

It would be highly desirable to standardize seed classes, and harmonize regulations and standards with internationally recognized organizations. This will help with membership of international and regional organizations that promote movement of varieties and seeds, such as the OECD seed schemes for varietal certification and accreditation and the International Seed Testing Association. If the Uzbek seed sector needs to play a role in the regional or global seed industry, membership and accreditation to international seed related organizations is essential.

Adopting feasible and acceptable field and seed standards, in line with standards

elsewhere, would help accelerate seed sector growth. All provincial laboratories, other than Khorezm and Karakapkastan, need a major overhaul of facilities and trainings to enhance the capacity of staff to learn new methods, procedures, and guidelines of seed testing.

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Chapter VI

Analysis of Adoption, Impacts, and Seed Demand of Improved Wheat Varieties in Uzbekistan

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6.1 Summary

In the six years after Uzbekistan's independence in 1991, the area under cotton reduced from two million to 1.4 million ha. This was mainly replaced by wheat – a strategic crop for food security – making it the second most important crop after cotton. During the same period, irrigated areas increased substantially. As a result, between 1991 and 2019, total wheat area increased from 0.63 million ha to 1.31 million (82% of which is irrigated) while average yield increased from 1.34 to 4.65 ton/ha leading total production to increase from 0.95 million tons to 6.09 million tons. While area expansion contributed to the disproportionately high increase in total production, the main driver has been the increase in productivity, which in turn is mainly driven by the use of improved varieties and crop management practices. The increase in cultivated areas and use of modern production techniques such as improved varieties, certified seed, and better agronomic management practices are believed to have been stimulated at least partly by farmers' desire to produce well above the Government quota, as they could sell any surplus production at higher market prices. While the increases in productivity are clearly evident, the level of adoption of improved varieties, their overall socio-economic impacts, and particularly their contribution to productivity gains are not known. This study tries to fill this gap by providing:

(i) Credible estimates of current levels of national and provincial adoption of improved varieties, with particular attention paid to release dates.
(ii) Analysis of farm and farmer characteristics and institutional factors that influence farmers' decisions and intensity of adopting improved wheat varieties.
(iii) Estimates of the impacts of adopting improved wheat varieties on farmers' livelihoods, in particular yields, gross margins, and wheat consumption.
(iv) Estimates of seed demand at farm, provincial, and national levels.

In doing so, the study aims to provide useful information and policy guidance to enhance the viability, sustainability, and socio-economic benefits, including household and national food security, of wheat production in Uzbekistan.

To this end, the study carried out two surveys – in 2013 and in 2018. In 2013, the study used a nationally representative sample of 1,526 farm households drawn from 126 villages across 36 districts and eight provinces. Together, these provinces constituted about 64% of the total 1.44 million ha national wheat area, and a similar percentage of the 4.11 million wheat-growing households in the country.

In the second survey in 2018, only 608 sample households were selected. This was done using a stratified sampling procedure from only three provinces (which together, account for only about 24% and 30% of total national wheat area and growers, respectively). The three provinces were purposely chosen from the eight provinces in the previous survey, because of resource constraints. Moreover, these three provinces were targeted by the CGIAR for the dissemination of improved winter wheat varieties. Therefore, there was specific interest in understanding the adoption and impacts particularly of these varieties. Data analysis was done using descriptive statistics, a Double Hurdle model, and an instrumental variables (IV) regression approach.

For the purpose of this study, new improved varieties are defined as varieties which are ten years old or under (i.e., varieties released in, or after, 2004 for the 2012/13 survey, and varieties released in, or after, 2007 for the 2016/17 survey). The total adoption rates reported for improved varieties are cumulative. To this effect, three cut-off points, namely five years old or less (i.e., between 0.1 and five years), 10 years old or less (i.e., between 0.1 and 10 years), and 20 years old or more (i.e., those 20 or more years old) from the official release dates were used for classifying varieties based on their age. Survey results show that during the 2012/13 cropping season, a total of 41 distinct wheat varieties were under cultivation by farmers in the eight surveyed provinces. Varieties released in the preceding 10, and five years were cultivated by 83% and 59% of all wheat growers, respectively, and covered 82%, and 58% of the total national wheat area in the same order. During this period, only 4% of the varieties in farmers' hands were more than 20 years old. These old varieties were cultivated on 3.1% of the total wheat area.

Looking at the three revisited provinces (Andijan, Qashqadarya, and Tashkent), 37 and 39 wheat varieties were under cultivation in the 2012/13 and 2016/2017 cropping seasons, respectively, showing a small increase in wheat biodiversity. The cumulative average adoption rates for utmost 20 years old (i.e., between 0.1 and 20 years old), utmost 10 years old (i.e., between 0.1 and 10 years old), and utmost five-year-old (i.e., between 0.1 and five years old) varieties during the 2012/13 cropping season were 92%, 81%, and 62%, covering 93%, 80.4%, and 56.8%, respectively of the total wheat area in the three provinces. In contrast, in 2016/17, about 97.1%, 81% and 41.3% of farmers in the three revisited provinces were cultivating 20, 10 and five years old varieties on 97.5%, 79.2% and 41.9%, respectively, of the total wheat area in the three provinces. As there could be major systematic differences between the eight provinces for wheat production, any time-based comparisons in this study are made using data from the three revisited provinces only. These results provide mixed pictures in terms of varietal adoption where Uzbekistan has been making good progress in taking more than 20 years old varieties out of production. However, while the overall varietal replacement has improved, the turnover for most recent (less than five years old) varieties has slowed down. This could possibly be explained by the reduction in the number of varieties released in the preceding five years from the specific survey years where it reduced from a total of 20 for 2012/13 to only 13 for the period 2016/17. Varietal replacement may also be affected by other factors including the effectiveness of extension service and input delivery systems (including seed), and the concordance between breeding objectives and farmers' trait preferences. However, this study was not able to provide full explanation for this undesirable result. Therefore, future research will need to find an explanation for why the speed of diffusion for less than five years old varieties has slowed down.

In the 2012/13 cropping season, the top 10 and top five wheat varieties were cultivated by 80% and 65.8% of wheat growers on 81% and 68% of the total wheat area, respectively. With the large number of varieties found in farmers' hands, this showed fairly high diversity of wheat varieties in the country. Six of the top 10 varieties, covering

about 60% of the national wheat area, were released after 2006 (less than six years). The top two varieties during the 2012/13 cropping season by number of growers were Tanya (released in 2010) and Krasnodarskaya99 (released in 2008). These two varieties were cultivated by 49.5% of Uzbek farmers covering 47.4% of total national wheat area. In the three revisited provinces alone, the top 10 and top five varieties were cultivated by 79.1% and 66.2% of wheat growers, on 84.38% and 70.2% of the total wheat area, respectively which is comparable to the national figures. The top two varieties in these three revisited provinces were Tanya and Bobur (released in 2013) which were grown by 31.2% and 13.4% of farmers and covered 29.1% and 14.1% of total wheat area which are comparable to the adoption levels for the top two varieties at the national level.

During the 2016/2017 cropping season, the top 10 and top five wheat varieties were cultivated by 79.1% and 60.7% of wheat growers on 80.8 % and 63% of the total wheat area, respectively. Eight of the top 10 varieties, covering about 80% of national wheat area, were released after 2006 (more than 10 years). The top two varieties by number of growers were Tanya and Grom (released in 2013), which were cultivated by 36.8% of the farmers on 34.7 % of total wheat area in the three provinces.

The joint ICARDA/CIMMYT/Turkey International Winter Wheat Improvement Program (IWWIP) based in Turkey, has released four rust-resistant varieties in Uzbekistan post 2012/13 wheat survey. Currently, while one variety called Shams was not found in farmers' hands, the remaining three – G'ozg'on (2015), Yaksart (2014), and Bunyodkor (2016) – were being cultivated by 8.6% of the farmers in the three revisited provinces, covering 8.13% of the total wheat area in the three revisited provinces. Despite the relatively short period since their release, the relatively high adoption level clearly shows the importance of the Uzbekistan-CGIAR collaboration.

The area-weighted average variety ages were 7.6 and 9.9 years in 2012/13 for all eight and the three revisited provinces, respectively indicating that varietal replacement in the revisited provinces was relatively slower than the national average. In contrast, the area-weighted varietal age in 2016/17 in the three revisited provinces was 6.6 years. This shows that in these three revisited provinces, varietal turnover was 33% faster in 2016/2017 than in 2012/13 – showing substantial progress. If we assume that there weren't systematic differences among the eight provinces between 2012/13 and 2016/17, one can expect the area-weighted average varietal age in all eight provinces to be less than 6.6 years.

Number of years of education of the household heads, use of certified seed, and access to credit, among other things, have positive and significant effects on whether farmers decide to adopt improved wheat varieties. Farmers who hosted demonstration trials on their own farms and those who had more contacts with extension agents about wheat production also had higher tendency to adopt improved wheat varieties. Therefore, continuing to encourage agriculture as a career for educated people in Uzbekistan, focusing on the latest improved varieties for certified seed production, improving credit systems to ensure better access to credit for farmers, and ramping up more demonstration trials on farmers' fields, may further improve adoption of recent wheat varieties.

In 2012/13, adopters of improved wheat varieties in the three revisited provinces obtained, on average, yield gains of about 735.61kg/ha (18%), income gains of 194,921.3 UZS or 93.7 USD (16.2%), and wheat consumption gains of 14.4 kg/capita/year (25.4%) indicating that the improved varieties have contributed to livelihoods improvements. In 2016/17, the yield, gross margin, and wheat consumption gains in the same provinces were 1353.86 kg/ha (25.5%), 367,364 UZS or 129.3 USD (25.1%), and 22.3 kg/capita/year (32.7 %), respectively. The gains in all three impact indicators more than doubled between 2012/13 and 2016/17, clearly showing the country's tremendous progress. Nationally, the introduction of improved wheat varieties in Uzbekistan has led to the production of 1.54 million tons of additional wheat every year. Overall, this has meant about 49.7 kg/capita/year higher wheat availability from domestic production and a national gain in net wheat income of about 2.1 trillion UZS or 0.74 billion USD per year.

In the three revisited provinces, the average seeding rate for wheat in the 2012/13 cropping season was 214 kg/ha. This was also almost the same in the 2016/17 cropping season. Given the five-year average total national wheat area of 1.44 million ha, the national seed utilization rate in 2016/17 was estimated at 308,160 tons per year. Official certified seed distribution data shows that a total of 293,906 tons of seed was distributed in 2015. This shows the certified seed use rate in the country was over 95.4% (100%*293,906/308,160), indicating an average seed replacement rate of 1.04 years. In other words, almost all farmers are replacing their seed every year. This result is consistent with the common knowledge that there is annual seed replacement among Uzbek farmers, except among the dehkans.

Among the eight provinces included in the first survey, the highest use of wheat seed was observed in Qashqadarya and Jizzakh (43,900 and 40,400 tons, respectively), while Navoi used the least (9,800 tons). Analyzing trends in the quantity of seed use between 2012/13 and 2016/17 showed that while there were increases in seed use in Andijan and Tashkent, the total quantity of seed used in Qashqadarya decreased. Tanya, Krasnodarskaya99, Bobur, Esaul, and Kroshka, in descending order, were the top five varieties with the highest seed use among the eight provinces included in the first survey. Tanya, Bobur, Krasnodarskaya99, Tezpishar, and Esaul were the top five varieties with the highest seed use in the revisited three provinces included in the first survey 2012/13 cropping season. Whereas in 2016/17, the top five varieties with the highest seed use in the three revisited provinces were Krasnodarskaya99, Grom, Tanya, Andijan4 and G'ozg'on. These results are consistent with official statistics on the total amount of certified seed produced and distributed.

In 2012/13, farmers in all the eight provinces and the revisited three provinces reported 83.93% and 90.78% of seed was certified, while the remaining 16.07% and 9.22% was uncertified, leading to average seed replacement rates of 1.19 and 1.11 years, respectively. This showed that most Uzbek farmers were replacing seed every year, with some replacing every two, three, or more years. The percentage of farmers in the three revisited provinces who used certified seed increased to 93% in the 2016/17 cropping season, leading to an average seed replacement rate of 1.07. Again, this showed clear

progress in the coverage of certified seed in the country. Farmers who were not replacing seed every year stated the main reason (72.4%) was the absence or non-availability of seed in sufficient quantities in the market. The second reason (27.9%) was high prices. In contrast, during 2016/17, farmers in the three provinces said 83% of total seed they used came from public seed companies and the remaining 17% was saved from their own grain production in the preceding year. The discrepancy between the common knowledge of annual seed replacement in Uzbekistan and our survey results are puzzling. Farmers suggested various ways to improve seed distribution and use:

1) Create better access to credit facilities for seed purchase and seed production under irrigation to increase seed availability (31%).
2) Seed companies should know better what farmers want and produce enough quantities of those varieties demanded (25.6%).
3) To be able to buy seed from local markets (16.5%) – we interpret this as farmers saying the informal sector needs strengthening to fill the gap or that they would like to buy seed from closer proximity (e.g., private sector) instead of the public seed distribution centers which may sometimes be far away.
4) Government should intervene and solve these problems to ensure availability and access to seed (12%).

We also found that gross margin decreased as the age of the variety increased. Therefore, to enhance adoption of most recent improved wheat varieties by farmers, policy makers and developers of new technologies must understand farmers' needs and trait preferences. Superiority in yield, marketability, and consumption qualities relative to the best varieties currently under cultivation should constitute the minimum breeding objectives if new improved varieties are to command higher and wider adoption.

6.2 Introduction

During the Soviet Union era, Uzbekistan's agriculture was developed primarily to supply the internal Soviet market with raw cotton (Trevisani, 2008). Other agricultural products such as wheat were exported to Uzbekistan from other Soviet states (Rudenko, 2008). After independence in 1991, increasing domestic winter wheat production became the Government's declared strategy to reduce dependency on imports (Guadagni et al., 2005).

In the first six years of independence, the area under cotton was reduced from two to 1.4 million ha and replaced mainly by wheat. To achieve food security, wheat became the second most important crop next to cotton (FAOStat, 2021, Guadagni et al., 2005). Wheat area substantially increased from 0.62 million ha in 1992 to 1.6 million ha in 2003 after which, it slowly declined to 1.3 million ha in 2019 (FAOStat, 2021).

Since independence, wheat area under irrigation has increased substantially and currently accounts for 82% of total national wheat area. Among other things, the increase in cultivated areas, government support, and farmers' desire to produce surplus which they

can sell for higher prices than those offered by Government under the quota system, are believed to have stimulated the use of modern production techniques. These included improved varieties, certified seed, and better agronomic practices. As a result, the average wheat yield increased almost three-fold from 1.66 ton/ha in 1992 to 4.65 ton/ha in 2019.

The combined effect of increased area and productivity during this period was an impressive increase in total production from 1.0 million tons in 1992 to 6 million tons in 2019 (Figure 6.1). In Uzbekistan, both common and durum wheat are grown under both irrigated and rainfed conditions and in winter and spring growing environments. On average, bread wheat constitutes 99% of total wheat area. The area of winter wheat increased rapidly from around 0.62 million ha in 1992 to 1.3 million ha in 2019, the majority (about 82%) of which is irrigated. Wheat accounts for about 31% of the total irrigated areas of Uzbekistan (FAOStat 2021).

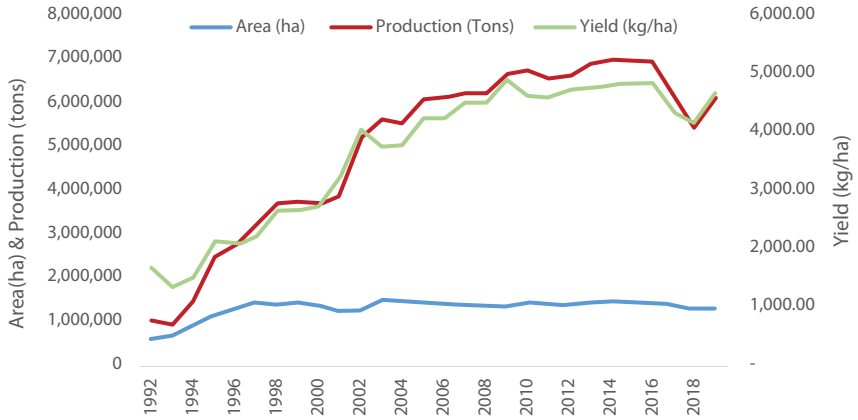

Figure 6.1: Trends in wheat area, yield, and production in Uzbekistan, 1992- 2019
Source: FAOStat (2021)

The share of agriculture in the total GDP of Uzbekistan is decreasing, but it still plays an important role in the country's economy. Agriculture accounts for 18% of GDP, and the livelihoods of 5.78 million rural people (i.e., 20.4% of the total population). Therefore, the three main objectives of Uzbekistan's agricultural policy today are:

1) To achieve food security and self-sufficiency in grain production
2) To improve rural standards of living
3) To maximize and stabilize export revenues from agricultural outputs (MAoWR, 2010, Mukhitdinova, 2010).

The country's agriculture has been gradually going through structural changes. Since its independence in 1991, the first step in the overall effort towards agricultural development was transforming state and collective farms into cooperative and private farms. In Uzbekistan, agricultural commodities are increasingly produced (from 4% in

1991 to 86% in 2016) by relatively large private farms (locally called fermer) which have average area size of about 50 ha. The share of smallholder farm households (locally called dehkan) with average area size of 0.5 ha has also nearly doubled from 7% in 1991 to 13% in 2016 (down by 2 percentage points from 2015). Since 2012, cooperatives (locally called shirkats) have started to constitute only a small (< 1.5%) share of agricultural area and production (Table 1). Though available data is limited, the share of these three types of producers in total wheat area has also followed similar trends. In Uzbekistan, smallholder households play an important role in producing food crops such as potatoes (84%), vegetables (67%), and fruits (52%). Nearly all local production of meat and milk in the country also comes from smallholders (SCS Uz., 2009).

Uzbekistan has a state procurement system for major crops including cotton and grains, where the Government determines the production quota (often set at levels higher than 50%) that farmers must sell to the Government (Pugach et al., 2016). The quotas reflect whether the land is in irrigated or rainfed environments and other growing conditions. Farmers are free to sell their surplus production in the open market – often at much higher prices (sometimes more than double) than what the Government pays. The crops, which have a state procurement price, are mainly produced by private farms.

As a result of the economic reforms in agriculture, private farms currently constitute the main share (over 85%) in agricultural production. Generally, these are large high-capacity farms with the latest machinery. These farms rent large areas of land from the Government for agricultural use. The total crop area cultivated by private farms is in the order of 2.9 million ha (over 85% of the total cultivated land in the country).

Irrigation plays a key role in the production of almost all crops in the country. The main sources of water for irrigation are rivers that originate in neighboring countries. Most farms face serious water scarcity for irrigation. This problem, together with fast population growth, makes it increasingly difficult for Uzbek farmers to produce enough food and other commodities (such as cotton) to meet domestic demand.

Table 6.1. Percentage share of different farm types in total food grain production and total wheat area in Uzbekistan

Year	Private Farms		Dehkan Farms		Public and Cooperative Agricultural Entities	
	Food grain production	Wheat area	Food grain production	Wheat area	Food grain production	Wheat area
1995	4%		7%		89%	
2000	14%		18%		68%	
2005	56%		16%		28%	
2010	84%		15%		1%	
2012	84%	86.1	15%	12.6	1%	1.3
2016	84.7%	86.8	13%	11.7	2.3%	1.5

Source: State Statistic Committee of the Republic of Uzbekistan
Note: with wheat being the most important food crop, the trend in total wheat production is believed to be similar to the total food grain production.

In 1991-1993, about four million tons of wheat was imported, which reduced to about one million and 0.4 million tons, respectively in 1996 and 1998. Since then, only small imports of wheat grain were made in pursuit of higher baking quality standards for domestic and export of wheat products to countries in the region and beyond. While Uzbekistan has achieved food self-sufficiency and no longer has to depend on imports (Guadagni et al. 2005), the domestically produced winter wheat falls short of meeting bakers' quality standards. Consequently, the amount of wheat imported for mixing with locally produced winter wheat to increase the baking quality, has generally increased since 2003 (Rudenko 2008).

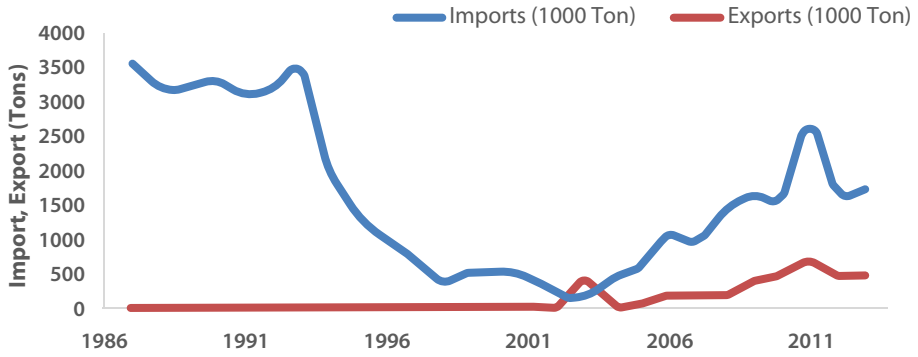

Figure 6.2. Trends in wheat imports and exports of Uzbekistan, 1987- 2014
Source: United States Department of Agriculture http://www.usda.gov/

6.3 Objectives of this report

This study aims to draw authoritative conclusions on adoption levels of improved wheat varieties and their impacts, based on reliable estimates generated using nationally representative data (from the 2012/13 crop season) and data from a small purposive sample (for 2016/2017). In particular, the report aims to:

1) Provide an exhaustive list of varieties in farmers' hands.
2) Estimate the adoption levels of improved wheat varieties (both in terms of % area and % of farmers) at national and provincial levels.
3) Determine the current variety adoption levels by name and agro-ecological classifications.
4) Identify the major determining factors for the adoption of improved wheat varieties.
5) Determine the types and sources of seed used by farmers and the reasons behind their decision to use these types and sources.
6) Estimate the total seed demand, by source.
7) Measure the impacts of adopting new improved wheat varieties on farm and household income, and wheat consumption.

6.4 Survey design

Data for this study comes from two surveys carried out in 2013 and 2018. In 2013, out of a total of 13 provinces, the team of researchers chose to include only eight major and representative wheat growing provinces. These were Karakalpakstan, Andijan, Bukhara, Jizzakh, Qashqadarya, Navoi, Samarkand, and Tashkent. The eight sample provinces cover over about 64% of total national wheat area and 75% of national wheat production.

Prior to the survey, the adoption level for improved wheat varieties of 10 or less years old was estimated by a team of experts to be utmost 60%. Using power analysis, the minimum sample size required to ensure 95% confidence and at least 2.5% precision levels for capturing up to 60% adoption of improved wheat varieties from among 2.61 million farmers in the eight sample provinces was calculated to be 1,475 households. The sample was inflated by about 3% to buffer the effects of possible higher adoption levels, missing values, non-response, erroneous entries, and to ensure a certain minimum sample size at village level – the primary sampling unit (PSU). Therefore, the team decided to sample 1,526 farm households. The team used a stratified sampling procedure to randomly select districts and villages. The total sample of 1,526 was then distributed among 36 districts and 126 villages, in proportion to the number of wheat farmers in each administrative unit.

In the second survey carried out in 2018, selection of sample provinces was goal-led where only three provinces (all drawn from among the eight provinces covered in 2013) were included. The three provinces namely, Andijan, Qashqadarya, and Tashkent (hereafter referred to as "revisited provinces"), were selected because dissemination of improved winter wheat varieties from the CGIAR had targeted them, so there was specific interest in understanding the adoption and impacts particularly of these varieties. These three revisited provinces constituted 24% of total national wheat area and 30% of total national wheat production in the 2016/2017 cropping season (Table 6.2). In the second survey, 608 sample households were selected using a stratified sampling procedure from 12 districts and 150 villages distributed across the three revisited provinces.

Distributions of sample farmers by province and farm sizes for 2012/13 and 2016/17 surveys are provided in Tables 6.3a and 6.3b, respectively. As there could be major systematic differences between the eight provinces in terms of wheat production, any time-based comparisons in this study using data from the two separate surveys are limited to only the three revisited provinces.

Table 6.2. Distribution of sample households for the wheat adoption study, Uzbekistan

Region	Province	Wheat area (ha)		Total number of wheat growers		Sample statistics 2012/2013					Sample statistics 2016/2017				
						No. of districts	No of villages	Number of Household-			No. of districts	No of villages	Number of Household-		
								Male headed	Women headed	Total			Male headed	Women headed	Total
		2013	2017	2013	2017										
Northern (Karakalpakstan, Horezm)	Karakal-pakstan	53000		202136		4	16	103	10	113					
Southern (Qashqadarya, Surkhandarya)	Bukhara	65600		347320		5	27	155	4	159					
	Qashqadarya	212286	144200	434866	8028	4	16	247	11	258	4	44	205	3	208
	Navoi	43400		142630		4	4	68	4	72					
Central (Jizzakh, Tashkent, Syrdarya)	Jizzakh	180000		157585		4	16	148	1	149					
	Samarkand	147455		484040		4	16	276	4	280					
	Tashkent	136100	120900	395981	6867	6	17	214	49	263	4	52	194	14	581
Fergana Valley (Andijan, Namangan, Fergana)	Andijan	80209	79400	445700	4098	5	14	215	17	232	4	54	182	10	192
Total sample		**918050**	**344500**	**2610258**	**18,993**	36	126	1426	100	1526	12	150	581	14	608
Total national		**1438000**	**1408343**	**4107026**	**5,697**										
Sample as % of national total		**64%**	**24%**	**64%**	**30%**										

Table 6.3a. Distribution of sample households for the wheat adoption study, Uzbekistan

Province	0 - < 1 ha	1 - < 3 ha	3 - < 5 ha	5 - < 10 ha	10 - < 20 ha	20 - < 50 ha	50 - < 100 ha	> 100 ha	Total
Karakalpakstan	3	5	5	33	62	5	0	0	113
Andijan	7	3	4	45	106	54	13	0	232
Bukhara	19	3	3	35	82	15	1	1	159
Jizzakh	36	0	2	43	67	1	0	0	149
Qashqadarya	0	14	34	112	45	47	5	1	258
Navoi	7	4	2	6	18	30	3	2	72
Samarkand	62	1	0	7	48	133	29	0	280
Tashkent	1	7	10	39	106	87	11	2	263
Total	135	37	60	320	534	372	62	6	1526
% of samples	8.8	2.4	3.9	21.0	35.0	24.4	4.1	0.4	100

Table 6.3b. Distribution of the sample by province and farm size 2016/2017 survey

Province	0 - < 1 ha	1 - < 3 ha	3 - < 5 ha	5 - < 10 ha	10 - < 20 ha	20 - < 50 ha	50 - < 100 ha	> 100 ha	Total
Andijan		0	0	0	4	116	69	3	192
Qashqadarya		7	2	13	20	103	49	14	208
Tashkent		6	7	40	59	48	41	7	208
Total		13	9	53	83	267	159	24	608
% of sample	0.0	2.1	1.5	8.7	13.7	43.9	26.2	3.9	100

6.5 Methodology

6.5.1 Modelling adoption of new agricultural technologies

The use of binomial and multinomial qualitative choice models to analyze adoption of technologies is well-established in adoption literature (Fikire and Zegeye, 2021; Teklewold et al., 2020; Ahmed, 2015). One purpose of qualitative choice models is to determine the probability that an individual with a given set of attributes will make one choice rather than an alternative (Green, 2000). The two most popular functional forms used for adoption models are the probit and logit models (Hiu et al., 2021; Finger and Benni, 2013; Teklewold and Marenya, 2020; Mariano et al., 2012; Ahmed, 2015; Wafula et al., 2015). Feder et al. (1985), define individual adoption (at farm or firm level) as the degree of use of new technology in the long-run equilibrium, when the farmer has full information about the new technology and it's potential. Dimara and Skuras (2003) argued the basic tenet of a single-stage decision-making process characterizing dichotomous adoption decision models is a direct consequence of the complete information assumption embedded in the definition of adoption. However, the full information assumption is often violated, and hence analysis of the adoption decision using logit, probit, and the associated tobit models, may suffer from model misspecification.

Over the years, many authors have tried to overcome these limitations. Byerlee and de Polanco (1986) suggested a sequential adoption decision model. Assuming that previous adoption models did not adequately consider the dynamic learning process, Abadi and Pannell (1999) suggested using a dynamic adoption decision model, including farmers' perceptions, managerial abilities, and risk preferences. Dimara and Skuras (2003) proposed a partial observability model based on the assumption that adoption of innovations is a multi-stage process. The sample population in previous adoption studies did not have the necessary information and awareness concerning the new technology (violating the complete information assumption).

To account for differential exposure among farmers, Diagne and Demont (2007) used the "treatment effect" framework to consistently estimate population adoption rates and their determinants for new rice varieties in Côte d'Ivoire. This study applied the two-stage regression method to correct for selectivity bias and endogeneity problems in the data. This represents an improvement compared to past technology adoption and impact studies. Accordingly, the first-stage probability of adoption estimate is derived, which accounts for farmers' prior exposure to the new varieties by including a participation variable. Results are subsequently used to correct for the treatment effect in a second-stage income equation.

For this study, we followed Yigezu et al. (2019a), in applying the Double Hurdle (DH) model (Cragg, 1971) to identify the determinants of farmers' decision-making process and intensity of adoption. Unlike dichotomous choice models, this method allows the determination of the intensity of use of agricultural technology once the decision to adopt is made. The DH approach, which sees the adoption decision as a two-step

decision, first analyzes the causal relationship between the adoption decision and other different factors, including farm and farmer characteristics, institutions, policy, infrastructure, and others.

In the first stage, the model uses a binary outcome dependent variable. This takes a value of "1" when a given farmer's observed decision is to adopt and "0" if the farmer is seen not to have adopted the improved varieties under consideration. In the second stage, the model estimates a regression model with a continuous variable (in our case, the wheat area cultivated using the improved varieties under consideration) as the dependent variable, with the same or different factors used in the first step as explanatory variables. In the second stage regression, the coefficients on each of the explanatory variables are estimated as the extent of change in the area used for the improved varieties in response to a unit change in the value of a given variable (factor). This is conditional on the fact that the farmer has already made the decision to use the improved varieties. This means farmers who've made the decision not to use improved varieties or those who wouldn't adopt improved varieties (i.e., farmers with a propensity score of zero) in the first step, are in effect excluded from the analysis in the second step.

Several studies used the DH approach to study adoption of different agricultural technologies (Yigezu et al., 2019; Kapalasa, 2014; Mignouna et al., 2011; Asfaw et al., 2010; Getachew et al., 2009; Shiferaw et al., 2008). In our case, the decision to adopt an improved variety is modeled as a binary variable; the latent variable underlying a household's decision to use the improved variety IT_i^* is specified as:

$$IT_i^* = x'_{1i}\beta_1 + \varepsilon_{1i} \qquad (1)$$

Where the vector x'_{1i} constitutes determinants of the adoption decision, β are parameters, and ε_{1i} is a normally distributed error term with mean zero and constant variance. The corresponding probit is estimated on the observed outcome $IT_i^*=1$ if $IT_i^*>0$ and 0 otherwise. Area planted to the improved variety (A_i^*) is also an unobserved latent value that can be specified as:

$$A_i^* = x'_{2i}\beta_2 + \varepsilon_{2i} \qquad (2)$$

Where x_{2i}' are determinants of the decision on the area allocated to the improved varieties of wheat, β_2 are parameters. Since A_i^* is a latent variable, we work with observed area (A_i). $A_i = A_i^*$ if $IT_i^*>0$ and $A_i=0$ if $IT_i^* \leq 0$. Because we use observed area, the error term (ε_{2i}) is assumed to have a truncated normal distribution. The β_1 and β_2 can be estimated separately because the Cragg likelihood function is separable.

6.4.2 Measuring the impacts of improved wheat varieties

Estimating treatment effects (Imbens and Angrist, 1994) has been the focus of the program evaluation literature. One of the main challenges in this pursuit is establishing counterfactuals, as selection bias is often inherent in program participation. Several econometric approaches can be used to address selection bias in program evaluation

by using quasi-experimental and observational data. Several studies provided good reviews of the literature on program evaluation and causal inference (Anderson et al, 2021; Cook et al, 2020; Linzalone and Schiuma, 2015; Imbens and Wooldridge, 2009).

Propensity score matching (Rosenbaum and Robin, 1983) is by far the most widely used for improving causal inference and estimating average treatment effects (Sseguya et al., 2021; Sonny et al., 2020; El-Shater et al., 2016; Morgan and Winship, 2014; Henderson and Chatfield, 2011; Jalan and Ravallion, 2003). Propensity score matching (PSM) helps correct biases introduced only by observable covariates (Heckman and Vytlacil, 2007). Therefore, results from PSM can sometimes be misleading, since unobservable factors such as skills and motivation can influence the outcome and the program participation decision, thereby leading to confounding errors (see Austin 2008 for critical review of PMS). The endogenous switching regression (Liu et al., 2021; Ojo et al., 2021; Maddala and Nelson, 1975) and instrumental variables (Angrist and Pischke, 2009) have been proposed to overcome this problem. Both methods account for the endogeneity of the participation decision and are potent ways to correct selection bias introduced by both observable and unobservable factors.

For this study, the instrumental variables regression (IV) approach is used to estimate the impacts of adopting improved varieties among Turkish farmers. IV is designed to remove both overt and hidden biases and deal with the problem of endogenous treatment in estimating causal effects of a treatment on an outcome (Angrist and Rubin, 1996). IV methods are becoming common in program evaluation and comparative effectiveness research (Knößlsdorfer et al., 2021; He and Perloff, 2016; Kumar and Mangyo, 2011; Heckman and Vytlacil, 2005; Manski and Pepper, 2000).

The IV method requires the "instrument" meets three important conditions:

1) The instrument has to be associated with the treatment.
2) The instrument must not affect the outcome except through the treatment – also known as the exclusion restriction assumption.
3) There aren't omitted variables affecting both the instrument and the outcome variables.

The reliability of the results from instrumental variables regression depends on the fitness of the instrument in fulfilling the above conditions (Imbens, 2004). Therefore, to measure the impacts of agricultural technologies, it's important to identify an instrument(s) which is (are) correlated with the decision to adopt, but uncorrelated with the unobserved factors that influence the outcome (Shahzad and Abdulai, 2021; Shiferaw et al., 2014; Alene and Manyong, 2007; Heckman, 1996).

Suppose there's endogeneity between the treatment variable X and the outcome variable Y. Suppose also that Z is a matrix of exogenous covariates, which qualify as valid instruments for X. Then the IV model can be described by equations 3 and 4.

$$y = X\beta + \varepsilon \qquad (3)$$

$$X = Z\beta + \mu \qquad (4)$$

Where and are vectors of coefficients and and μ are the error terms; and, E[X^T] ≠ 0, E[Z^T μ] = E[Z^T] = 0, Var() = ^2 ,Var(μ) = μ^2 and Cov(,μ) = μ, which is a measure of the level of endogeneity between the treatment and outcome variables. The two-stage least squares (2SLS) estimating procedure is then used to estimate equations 3 and 4 jointly, where equation 4 is estimated first and then the predicted values used in equation 3 in place of the observed values of X.

To estimate a variant of the Cobb-Doughlas production function, which takes a log-linear form, a logarithmic transformation has been made on all continuous variables such as yield, gross margins, consumption, farmer age, years in education, wheat area, and all quantities of inputs included either as dependent or explanatory variables in the IV regression. Several factors such as the amounts of fertilizers, seed, and labor are important in determining yield, income and consumption. Therefore, all these variables are included as explanatory variables in the model.

Tests of over-identifying restrictions are also carried to test two different things simultaneously. First, it's used to test whether the instruments are uncorrelated with the error term. Second, the test is used to detect if the equation is mis-specified and that one or more of the excluded exogenous variables should be included in the structural equation. Thus, a significant test statistic could represent either an invalid instrument or an incorrectly specified structural equation.

The Hausman test for endogeneity and the Durbin (1954) and Wu–Hausman (Wu, 1974; Hausman, 1978) statistics, reported after 2SLS estimation with a robust VCE, were also evaluated if endogeneity was a problem. In all cases, if the test statistic is significant and hence the null hypothesis of exogenous treatment is rejected, then the treatment variable must be regarded as endogenous – justifying the use of the IV or any other approach effective at correcting for endogeneity. Version 15 of the Stata software (StataCorp, 2017) was used for all econometric estimations in this study.

6.6 Results

6.6.1 Characterization of the sample wheat grain

In 2012/2013, about 6.6% of the heads of households were women. The percentages of women-headed households in the three provinces, appearing in both surveys (2012/2013 and 2016/17) were about 7% and 4.4%, respectively. A sizeable proportion (63%) of the household heads were relatively old (>50 years old) and married men. Agriculture is the main source of employment for more than 90.6% of the respondents in the 2012/13 cropping season and 91% and 92.3% of the respondents for the revisited three provinces in 2012/13 and 2016/2017 cropping seasons, respectively. Most (65% and 67.8%, respectively) of the household heads were members of local organizations and/or associations in the three revisited provinces in 2012/13 and 2016/2017 cropping seasons, respectively (Table 6.4). While only 22% and 25.2% of them were community leaders in the 2012/13 and 2016/17 cropping seasons, respectively.

Table 6.4. Characteristics of household heads

	All 8 provinces (2012/13 cropping season)			Only the revisited three provinces (2012/13 cropping season)			Only the revisited three provinces (2016/17 cropping season)		
Variable	**Minimum**	**Average**	**Maximum**	**Minimum**	**Average**	**Maximum**	**Minimum**	**Average**	**Maximum**
Percentage of respondents which are household heads		90.6%			91			94.7	
Percentage of female household heads		6.6%			7			4.4	
Percentage of married household heads		99.1%			95			96	
Percentage of household heads for which agriculture is the main source of employment		90.6%			91			92.3	
Is household head a member of any community leadership		20.7%			22			25.2	
Is the household head a member of any organization or association		63.6%			65			67.8	
Age of household head (years)	20	47.1	87	22	46	80	21	45.5	72
Number of years the respondent has been living in this village	3	44	87	4	43	80	10	44.5	72

The average family size in the surveyed farm households is 7.69 and 6.22 in the two cropping seasons, respectively, out of which 52% and 53% are male. The age structure of a given population is an important indicator to know the extent of each age group's contribution to the economic activity of any society. The typical Uzbek farm household is composed of family members in a wide range of age distribution, where most (about 55% and 59% in 2012/13 and 2016/17, respectively) were in the 15-65-year-old group. These were the most productive and economically active and able to work (Table 5).

Table 6.5. Household demographics

	All 8 provinces (2012/13 cropping season)			Only the revisited three provinces (2012/13 cropping season)			Only the revisited three provinces (2016/17 cropping season)		
Age group	**Minimum**	**Mean**	**Maximum**	**Minimum**	**Mean**	**Maximum**	**Minimum**	**Mean**	**Maximum**
Total	**0**	**7.69**	**42**	**0**	**6.73**	**23**	**2**	**6.22**	**21**
<7 years old	0	1.33	21	0	0.82	7	0	0.87	8
8-15 years old	0	1.39	12	0	1.61	15	0	1.21	8
15 – 65 years old	0	4.24	12	0	4.07	16	1	3.96	18
> 65 years old	0	0.73	13	0	0.22	3	0	0.89	5
Total Male	**0**	**3.97**	**28**	**0**	**3.35**	**10**	**1**	**3.27**	**16**
male <7 years old	0	0.71	14	0	0.42	3	0	0.49	7
male 8-15 years old	0	0.70	5	0	0.76	4	0	0.63	4
male 15 – 65 years old	0	2.18	7	0	2.05	7	0	2.07	16
male > 65 years old	0	0.38	7	0	0.11	1	0	0.08	1
Total female	**0**	**3.72**	**24**	**0**	**3.38**	**13**	**0**	**2.94**	**9**
Female <7 years old	0	0.62	12	0	0.4	4	0	0.38	4
Female 8-15 years old	0	0.70	11	0	0.85	11	0	0.58	5
Female 15 – 65 years old	0	2.06	9	0	2.02	9	0	1.89	7
Female > 65 years old	0	0.35	6	0	0.11	2	0	0.11	4

Most (90% and 82%, respectively) of the farm households in the revisited three provinces in 2012/13 and 2016/2017 cropping seasons, respectively, derived their income mainly from agriculture. For the typical sample farm household, agriculture constituted 73% and 70% of total family income. For some households in the survey, the contribution of agriculture to family income went as high as 100%, while for a few others, it went as low as 4% (Table 6.6).

Table 6.6. Share of agriculture in family income

	All 8 provinces (2012/13 cropping season)			Only the revisited three provinces (2012/13 cropping season)			Only the revisited three provinces (2016/17 cropping season)		
	Minimum	**Mean**	**Maximum**	**Minimum**	**Mean**	**Maximum**	**Minimum**	**Mean**	**Maximum**
Percentage of households for which agriculture is main source of income		90.3			89			81.7	
Share of agriculture in total family income	4	73	100	3	73.4	100	20	70	100

Regarding the contribution of family labor to agriculture, only 60% of family members who were in the productive age range of 15-65 years old, were involved in own-farm activities, spending on average 73% and 70% of their time on own-farm activities in 2012/13, and 2016/17, respectively. Most (72% and 70% respectively in 2012/13 and 2016/17) of family farm labor contribution came from male members (Table 6.7).

Table 6.7. Family labor in agriculture

	All 8 provinces (2012/13 cropping season)			Only the revisited three provinces (2012/13 cropping season)			Only the revisited three provinces (2016/17 cropping season)		
	Minimum	**Mean**	**Maximum**	**Minimum**	**Mean**	**Maximum**	**Minimum**	**Mean**	**Maximum**
Total number of family members working on family farm	0	2.56	12	0	2.5	11	0.2	2.7	13
Number of male family members working on family farm	0	2	8	0	1.8	7	0.2	1.9	7
Number of female family members working on family farm	0	0.56	4	0	0.5	3.8	0	0.8	6
Percentage of time spent on agriculture by family members working on own farm	7	73.25	100	8	69	100	12	70	100

The average cultivated farm size among the sample households in 2012/13 was 89.52 ha (95% irrigated), where the typical farm household cultivated about 65.95 ha - 80% of the total crop area (Table 6.8). The average farm sizes among the sample households in the three provinces, appearing in both surveys (2012/2013 and 2016/17) were 72.67 ha and 42.6 ha, respectively. The majority of the sample farmers use irrigation (from rivers) for crop production.

Table 6.8. Land holding

Landholding type	All 8 provinces (2012/13 cropping season)	Only the revisited three provinces	
		During the 2012/13 cropping season	During the 2016/17 Cropping season
Landholding	Mean	Mean	Mean
Total crop area (ha)	89.52	72.67	49.2
Total cultivated crop area (ha)	65.95	56.9	42.6
Source of water (%)			
Rain	5.04	4	4.98
River	94.07	95	94.28
Ground water	0.89	1	0.74

In the first survey carried in 2013, the area coverage of cotton in the three revisited provinces still ranked first, but for only 60% of sample farmers, while wheat ranked first for the remaining 40% farm households. During the second survey carried in 2018, wheat ranked 1st for 79.6% of the farmers, with cotton ranking second. In 2012/13, 84% of sample farmers in the three revisited provinces reported that for their household, 10 years before the survey year, cotton ranked first for area coverage, while for the remaining 16% of farm households wheat ranked first. In the 2016/17 survey year, 63.5% farmers in the three revisited provinces said that 10 years before the survey year, wheat ranked first (Table 6.9).

Table 6.9. Importance of crops in farmers' crop portfolios

	All 8 provinces (2012/13 cropping season)			Only the Revisited three provinces (2012/13 Cropping season)			Only the Revisited three provinces (2016/17 Cropping season)		
	Rank of major crops cultivated or fallow			Rank of major crops cultivated or fallow			Rank of major crops cultivated or fallow		
Crop rank	1	2	3	1	2	3	1	2	3
Cotton	60.5	34.6	4.9	60	33	7	20.4	66.7	0
Cotton five years ago	79.9	14	6.1	80	15	5	52.1	23.7	0
Cotton ten years ago	87.2	4.9	7.9	84	7	9	63.5	4.9	0
Wheat	39.5	60.5	0	40	60	0	79.6	33.2	0
Wheat five years ago	20.1	79.9	0	20	77	0	47.9	76.3	0
Wheat ten years ago	12.8	84.5	2.8	16	85.2	1.7	36.5	95	0

Our results show machinery ownership is low, with only 21% of sample farm households owning tractors and only 5% owning combine harvesters (Table 10). However, 90% of wheat area is cultivated using tractors and 84% harvested using combine harvesters – showing that the share of machinery-operated land relative to total cultivated land is fairly high, which could possibly be explained by the use of machinery rental services. Livestock production is also an important activity in the survey areas, with the typical farm household owning about six cattle and eight small ruminants (Table 6.10).

Table 6.10. Asset ownership among sample farmers

	All 8 provinces (2012/13 cropping season)			Only the Revisited three provinces (2012/13 Cropping season)			Only the Revisited three provinces (2016/17 Cropping season)		
Asset/Indicator	**Minimum**	**Mean**	**Maximum**	**Minimum**	**Mean**	**Maximum**	**Minimum**	**Mean**	**Maximum**
Number of rooms in the house	2	6	12	2	5.6	11	1	5.9	15
Estimated value of the house ('000,000 UZS)	2.80	50.22	2000	0.30	48.32	2000	2.50	141.06	1000
Number of Tractors owned	0	1.12	9	0	1	7	0	1.1	6
Number of combine harvesters owned	0	0.03	3	0	0.03	2	0	0.05	3
Number of water pumps owned	0	0.29	3	0	0.3	3	0	0.5	4
Number of cars/picks-ups owned	0	0.79	4	0	0.6	3	0	0.6	3
Number of trucks owned	0	0.08	2	0	0.06	2	0	0.06	2
Number of cattle (oxen and cows) owned	0	5.52	170	0	6	100	0	8.2	125
Number of small ruminants (sheep, goats) owned	0	7.81	332	0	9	270	0	17.6	342

6.6.2 Adoption of improved wheat varieties

In this study, new improved varieties are defined as varieties which are ten years old or under (i.e., varieties released in, or after, 2004 for the 2012/13 survey, and varieties released in, or after, 2007 for the 2016/17 survey). The total adoption rates reported for improved varieties are cumulative. To this effect, three cut-off points, namely five years old or less (i.e., between 0.1 and five years), 10 years old or less (i.e., between 0.1 and 10 years), and 20 years old or more (i.e., those 20 or more years old)) from the

official release dates were used for classifying varieties based on their age.

6.6.2.1 Adoption rates by variety (Percentage of Farmers Cultivating Improved Varieties)

In the 2012/13 cropping season, a total of 41 distinct wheat varieties were found in farmers' hands. During this time, the top 10 varieties were being cultivated by 80% of wheat growers. A closer look at these varieties revealed six of them were released in, or after 2006. This showed there was high varietal turnover relative to Morocco (Yigezu et al., 2019b) and Turkey (El-Shater et al., 2021). It's worth noting the top two varieties by number of growers nationally, were Tanya (first released in 2010) and Krasnodarskaya99 (released in 2008). These two varieties were being cultivated by 49.5% (33.9% for Tanya and 15.5% for Krasnodarskaya99) of Uzbek farmers (Table 11). In the three revisited provinces, 37 varieties were found in farmers hands in 2012/13, during which the top 10 and top five varieties were being cultivated by 79.1% and 66.2% of wheat growers, respectively. The top two varieties in these three revisited provinces were Tanya and Bobur, which together were cultivated by 44.6% of farmers on 45.1% of total area. The area-weighted average varietal age in 2012/13 for all eight and three revisited provinces were 7.6 and 9.9 years, respectively. Bishaw (2004) also found that the five top wheat varieties in Ethiopia were grown by 56% of the sample farmers on 80% of the total wheat area, whereas in Syria it was 78% and 81%, respectively - showing low spatial diversity of improved varieties on farmers' fields. Likewise, it was reported that the area-weighted average age of wheat varieties was 13.35 years for bread wheat in Ethiopia and 10.82 years for Syria. These results showed that farmers in Syria tend to replace modern wheat varieties in relatively shorter period of time and therefore obtain better benefit from newly released varieties compared to farmers in Ethiopia.

In the 2016/17 cropping season, out of 39 wheat varieties found in farmers' hands, the top 10 varieties were being cultivated by 79.11% of wheat growers, of which eight were released on, or after, 2006. The area-weighted average varietal age in 2016/17 was 6.6 years. This shows that in the three revisited provinces, varietal turnover was 33% faster in 2016/2017 than in 2012/13 – indicating good progress over the years. The top two varieties by number of growers were Tanya and Grom (released in 2013), both of which were being cultivated by 34.7% of Uzbek farmers (i.e., by 17.4% and 17.2% of farmers, respectively) on 36.8 % of total wheat area in the three provinces. These results showed better varietal diversification (39 varieties) in 2016/2017 than the 37 varieties in 2012/13 (Table 6.11).

Table 6.11. Adoption rate (% of growers) by varieties

	All 8 provinces (2012/13 cropping season)					Only the three revisited provinces (2012/13 cropping season)					Only the three revisited Provinces (2016/17 Cropping season)				
Adoption Rank	Variety name	Year of release	Adoption rate (% of farmers)	Cumulative adoption rate (%)		Variety name	Year of release	Adoption Rate (% of farmers)	Cumulative adoption rate (%)		Variety name	Year of release	Adoption Rate (% of farmers)	Cumulative adoption rate (%)	
1	Selyanka Odesskaya	2006	33.9	33.9		Selyanka Odesskaya	2006	31.2	31.2		Grom	2013	17.4	17.4	
2	Krasnovodopadskaya 210	1980	15.5	49.4		Bobur	2006	13.4	44.6		Selyanka Odesskaya	2006	17.3	34.70	
3	Bobur	2006	8.5	58.0		Krasnovodopadskaya 210	1980	12.5	57.1		Krasnovodopadskaya 210	1980	16.9	51.64	
4	Nikoniya	2006	4.4	62.3		Matonat	2012	5.2	62.3		Vassa	2016	4.8	56.41	
5	Andijan2	2003	3.5	65.8		Durdona	2009	3.9	66.1		Yaksart	2011	4.3	60.69	
6	Durdona	2009	3.5	69.3		Nikoniya	2006	3.2	69.3		Gozgon	2013	4.1	64.80	
7	Matonat	2012	3.3	72.6		Tezpishar	1980	2.8	72.1		Bobur	2006	3.9	68.75	
8	Starshina	1900	2.6	75.2		Elita	1900	2.5	74.6		Andija4	2004	3.8	72.53	
9	Kinyajna	2000	2.5	77.7		Umanka	2000	2.4	77.0		Kinyajna	2000	3.8	76.32	
10	Umanka	2000	2.2	79.9		Nota	2010	2.0	79.0		Andijan1	2008	2.8	79.11	
11	Nota	2010	1.4	81.3		Esaul	2011	1.9	80.9		Gratsiya	2013	2.6	81.74	
12	Tezpishar	1980	1.4	82.6		Andijan1	2008	1.7	82.6		ASR	2013	2.3	84.05	
13	Turaqurgon_11	2005	1.4	84.0		Intensivnaya	1981	1.7	84.3		Umanka	2000	2.1	86.18	
14	Elita	1900	1.2	85.3		Kinyajna	2000	1.7	86.1		Mars1	2006	1.8	87.99	
15	Yaksart	2011	1.2	86.4		Tanya	2010	1.5	87.5		Hazrati Ibashir	2016	1.8	89.80	
16	Andija4	2004	1.1	87.6		Polovchanka	1999	1.3	88.8		Kokbulak	2001	1.3	91.12	
17	Esaul	2011	1.0	88.5		Zumrad	2001	1.2	90.0		Rapsodia	2013	1.2	92.27	
18	Moskvich	2010	1.0	89.5		Kuma	2010	1.1	91.1		Tezpishar	1980	1.0	93.26	
19	Tanya	2010	1.0	90.5		Kroshka	2000	1.1	92.2		Vostorg	2010	.8	94.08	
20	Andijan1	2008	0.9	91.4		Krasnodarskaya99	2008	0.9	93.1		Muftallo	2015	.7	94.74	
21	Intensivnaya	1981	0.9	92.3		Panyat	2010	0.9	94.0		Lebed	2016	.7	95.39	
22	Gratsiya	2013	0.7	92.9		Andija4	2004	0.8	94.8		Dustlik	2005	.5	95.89	
23	Kroshka	2000	0.7	93.6		Saidaziz	2010	0.8	95.6		Esaul	2011	.5	96.38	
24	Panyat	2010	0.7	94.2		Vostorg	2010	0.7	96.3		Zumrad	2001	.3	96.71	
25	Polovchanka	1999	0.7	94.9		Andijan2	2003	0.5	96.8		Krasnodarskaya99	2008	.3	97.04	
26	Vostorg	2010	0.6	95.5		Gratsiya	2013	0.5	97.3		Matonat	2012	.3	97.37	
27	Zumrad	2001	0.6	96.1		COTTON	2005	0.5	97.9		Semurg'	2010	.3	97.70	
28	Kuma	2010	0.5	96.6		Surkhon	1900	0.4	98.3		Zemnitsa	2016	.3	98.03	
29	ASR	2013	0.5	97.1		Kokbulak	2001	0.3	98.5		Zvezda	2016	.3	98.36	
30	Krasnodarskaya99	2008	0.5	97.5		Kupava	1999	0.3	98.8		Andijan2	2003	.2	98.52	
31	Saidaziz	2010	0.5	98.0		Moskvich	2010	0.3	99.1		Bahmal97	2012	.2	98.68	
32	Chillaki	2002	0.4	98.4		Turaqurgon_11	2005	0.3	99.3		Grekum439	1983	.2	98.85	
33	Turkiston	2011	0.3	98.7		Grom	2013	0.1	99.5		Jayhun_Zamin2	2007	.2	99.01	
34	COTTON	2005	0.3	99.0		Sanzar4	1999	0.1	99.6		Intensivnaya	1981	.2	99.18	
35	Kupava	1999	0.3	99.2		Tezpishar	1980	0.1	99.7		Oq Bugdoy	1993	.2	99.34	
36	Kokbulak	2001	0.2	99.4		Turkiston	2011	0.1	99.9		Sanzar4	1990	.2	99.51	
37	Surkhon	1900	0.2	99.6		Yaksart	2011	0.1	100.0		Chillaki	2002	.2	99.67	
38	Grom	2013	0.1	99.7							Yulka	2016	.2	99.84	
39	Jayhun_Zamin2	2007	0.1	99.8							Bunyodkor	2014	.2	100.00	
40	Sanzar4	1999	0.1	99.9											
41	Tezpishar	1980	0.1	100											
	Total		100												

Note: Entries highlighted in gray color represent rust-resistant varieties originated from IWWIP - a joint Turkey-CIMMYT-ICARDA program based in Turkey. Out of four varieties released in Uzbekistan, three (Gozgon, Yaksart, and Bunyodkor) were cultivated by 8.6% of all wheat farmers in the three revisited provinces. The fourth variety (Shams) was not found in farmers' hands.

6.6.2.2 Adoption rate by province

In the 2012/13 cropping season, the adoption rate for newly released varieties is highest in Karakalpakstan province, with 75.2% of farmers cultivating varieties five years old or under, followed by Jizzakh, Navoi and Bukhara, whose adoption rates for such varieties were 71.8%, 69.4% and 69.2%, respectively. At 84.5%, the adoption rate for varieties 10 years old or under is highest in Qashqadarya, followed by Karakalpakstan and Andijan, whose adoption rates for such varieties were 80.6% and 78.4%, respectively. Conversely, Tashkent had the highest percentage of farmers cultivating very old varieties, with 18.3% of growers cultivating varieties more than 20 years old at the time (Table 6.12). The high concentration of dehkan farmers in this province might explain this in whole or in part.

By comparing the three provinces (Andijan, Qashqadarya, Tashkent) included in both surveys, we found adoption rates for varieties released five years before the survey in 2012/13 for Tashkent, Qashqadarya, and Andijan, were 55.1%, 63.2%, and 67.24%, respectively. The corresponding figures in 2016/17 were 46.15%, 45.7%, and 32.8 %, respectively. This showed some reduction in the replacement of older varieties by most recent (less than five-year-old) varieties. The reduction in the number of new varieties released after 2013 might provide part of the explanation.

Table 6.12. Percentage of farmers planting wheat varieties from different release dates – by province

	All 8 provinces (13/2012 cropping season)								Only the three revisited provinces (2012/13 cropping season)			Only the three revisited Provinces (2016/17 cropping season)		
Released in or after this year	Karakalpakstan	Andijan	Bukhara	Jizzakh	Qashqadarya	Navoi	Samarkand	Tashkent	Andijan	Qashqadarya	Tashkent	Andijan	Qashqadarya	Tashkent
1900	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1953	100.00	100.00	100.00	100.00	100.00	100.00	100.00	92.78	100.00	100.00	92.78	100.00	100.00	100.00
1980	100.00	100.00	100.00	100.00	98.84	100.00	100.00	92.78	100.00	98.84	92.78	100.00	100.00	100.00
1981	100.00	97.84	100.00	100.00	98.84	100.00	100.00	81.75	97.84	98.84	81.75	100.00	97.12	99.52
1983	100.00	97.84	100.00	100.00	95.35	100.00	100.00	81.75	97.84	95.35	81.75	100.00	96.15	99.52
1990	100.00	97.84	100.00	100.00	95.35	100.00	100.00	81.75	97.84	95.35	81.75	100.00	96.15	99.04
1991	100.00	97.84	100.00	100.00	95.35	100.00	100.00	81.75	97.84	95.35	81.75	100.00	92.79	99.04
1993	100.00	97.84	100.00	100.00	95.35	100.00	100.00	81.75	97.84	95.35	81.75	100.00	92.79	98.56
1995	100.00	92.24	96.23	100.00	95.35	100.00	100.00	80.99	92.24	95.35	80.99	100.00	92.79	98.56
1999	95.58	92.24	96.23	100.00	95.35	98.61	100.00	80.99	92.24	95.35	80.99	100.00	92.79	98.08
2000	95.58	90.95	96.23	100.00	93.80	98.61	98.57	79.85	90.95	93.80	79.85	100.00	89.90	97.12
2001	93.81	85.34	91.82	89.26	91.09	93.06	93.21	78.71	85.34	91.09	78.71	98.44	89.90	87.50
2002	92.92	84.05	91.82	89.26	89.92	93.06	93.21	78.33	84.05	89.92	78.33	98.44	88.94	87.02
2003	92.92	82.33	89.94	87.25	84.50	80.56	93.21	78.33	82.33	84.50	78.33	92.71	87.98	87.02
2004	80.53	80.60	76.73	77.85	84.50	80.56	93.21	78.33	80.60	84.50	78.33	92.19	87.98	87.02
2005	80.53	78.45	75.47	77.85	84.11	77.78	76.43	78.33	78.45	84.11	78.33	80.73	87.50	87.02
2006	80.53	78.45	75.47	77.85	84.11	77.78	76.43	76.81	78.45	84.11	76.81	80.73	87.50	87.02
2007	76.99	75.43	71.07	75.17	84.11	77.78	76.07	73.38	75.43	84.11	73.38	78.13	79.33	86.06
2008	76.99	75.43	71.07	75.17	78.68	77.78	75.71	73.38	75.43	78.68	73.38	77.60	79.33	85.10
2009	75.22	67.24	69.18	71.81	63.18	69.44	30.00	55.13	67.24	63.18	55.13	38.54	70.67	72.12
2010	75.22	67.24	69.18	71.81	63.18	69.44	30.00	55.13	67.24	63.18	55.13	38.54	70.19	71.15
2011	0.88	34.05	9.43	4.03	6.98	56.94	8.93	19.39	34.05	6.98	19.39	32.81	45.67	46.15
2012	0.88	32.33	9.43	4.03	6.59	23.61	8.93	9.89	32.33	6.59	9.89	32.81	45.67	46.15
2013	0.88	31.90	9.43	4.03	6.59	23.61	7.50	9.89	31.90	6.59	9.89	32.29	39.90	46.15
2014	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.38	34.13	7.69
2015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.38	28.85	0.48
2016	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.38	26.92	0.48

6.6.2.3 Adoption rate – national level

In the 2012/13 cropping season, even though some provinces had low adoption levels for recent varieties, the national average adoption rate for such varieties was generally high. For example, 59.1% of Uzbek wheat growers cultivated varieties which were five years old or under at the time – an adoption level which is much higher than those obtained in Morocco (Yigezu et al., 2019b) and Turkey (Elshater et al., 2021). Theoretically, it is unjustifiable to expect newly released varieties to cover 59% % of total area in only four or even five years because, given the average yield of 5,700 kg/ha and seeding rate of 222 kg/ha, a multiplication factor of 25, starting from an assumed 10 kg of breeder seed, sufficient seed increase to cover 59% of total wheat area can be achieved only after seven years. Therefore, one possible explanation for such a rapid expansion of these recent varieties is that the country has an effective mechanism, which enables rapid bulking of sufficient early generation seed even before the variety is released. The corresponding figure in 2012/13 for only the three revisited provinces was 62.1%. During this time, only 17.44% of the growers were cultivating varieties that were 10 or more years old, and 3.9% of growers cultivating 20 or more years old varieties. During the same period, the average adoption rates of varieties that were 10 or more, or 20 or more years old were 18.8% and 10.2%, respectively (Table 6.13).

Table 6.13. Percentage of farmers planting wheat varieties from different release dates – national figures (Adoption rates are generated by using the number of growers in each province as weights)

	All 8 provinces (2012/13 cropping season)										Only the three revisited provinces (2012/13 cropping season)					Only the three revisited Provinces (2016/17 cropping season)				
Released in or after this year	Karakalpakstan	Andijan	Bukhara	Jizzakh	Qashqadarya	Navoi	Samarkand	Tashkent	Total	Cumulative	Andijan	Qashqadarya	Tashkent	Total	Cumulative	Andijan	Qashqadarya	Tashkent	Total	Cumulative
1900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.10	1.10	100.00	0.00	0.00	2.24	2.24	100.00	0.00	0.00	0.00	0.00	100.00
1953	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.19	98.90	0.00	0.40	0.00	0.40	97.76	0.00	0.00	0.00	0.00	100.00
1980	0.00	0.37	0.00	0.00	0.00	0.00	0.00	1.67	2.04	98.71	0.75	0.00	3.42	4.17	97.36	0.00	0.98	0.15	1.13	100.00
1981	0.00	0.00	0.00	0.00	0.58	0.00	0.00	0.00	0.58	96.67	0.00	1.19	0.00	1.19	93.19	0.00	0.33	0.00	0.33	98.87
1983	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	96.09	0.00	0.00	0.00	0.00	92.00	0.00	0.00	0.15	0.15	98.54
1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	96.09	0.00	0.00	0.00	0.00	92.00	0.00	1.15	0.00	1.15	98.39
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	96.09	0.00	0.00	0.00	0.00	92.00	0.00	0.00	0.15	0.15	97.25
1993	0.00	0.96	0.50	0.00	0.00	0.00	0.00	0.12	1.57	96.09	1.96	0.00	0.24	2.19	92.00	0.00	0.00	0.15	0.15	97.10
1995	0.34	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.42	94.51	0.00	0.00	0.00	0.00	89.81	0.00	0.00	0.15	0.15	97.10
1999	0.00	0.22	0.00	0.00	0.26	0.00	0.26	0.17	0.92	94.10	0.45	0.53	0.35	1.33	89.81	0.00	0.98	0.30	1.28	96.95
2000	0.14	0.96	0.59	0.65	0.45	0.30	0.99	0.17	4.25	93.18	1.96	0.92	0.35	3.23	88.48	0.55	0.00	2.98	3.53	95.67
2001	0.07	0.22	0.00	0.00	0.19	0.00	0.00	0.06	0.54	88.93	0.45	0.40	0.12	0.97	85.24	0.00	0.33	0.15	0.48	92.14
2002	0.00	0.29	0.25	0.12	0.90	0.68	0.00	0.00	2.25	88.39	0.60	1.85	0.00	2.45	84.28	2.00	0.33	0.00	2.33	91.66
2003	0.96	0.29	1.76	0.57	0.00	0.00	0.00	0.00	3.58	86.13	0.60	0.00	0.00	0.60	81.83	0.18	0.00	0.00	0.18	89.33
2004	0.00	0.37	0.17	0.00	0.06	0.15	3.11	0.00	3.86	82.56	0.75	0.13	0.00	0.88	81.22	4.00	0.16	0.00	4.16	89.15
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.23	78.69	0.00	0.00	0.47	0.47	80.34	0.00	0.00	0.00	0.00	84.99
2006	0.27	0.52	0.59	0.16	0.00	0.00	0.07	0.52	2.12	78.46	1.05	0.00	1.06	2.11	79.87	0.91	2.78	0.30	3.99	84.99
2007	0.00	0.00	0.00	0.00	0.90	0.00	0.07	0.00	0.97	76.34	0.00	1.85	0.00	1.85	77.75	0.18	0.00	0.30	0.48	81.00
2008	0.14	1.40	0.25	0.20	2.58	0.46	8.48	2.77	16.27	75.37	2.86	5.28	5.66	13.80	75.90	13.64	2.95	4.03	20.61	80.52
2009	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	59.09	0.00	0.00	0.00	0.00	62.10	0.00	0.16	0.30	0.46	59.90
2010	5.76	5.67	7.95	4.09	9.36	0.68	3.91	5.42	42.84	59.09	11.59	19.15	11.09	41.82	62.10	2.00	8.35	7.75	18.11	59.44
2011	0.00	0.29	0.00	0.00	0.06	1.82	0.00	1.44	3.62	16.25	0.60	0.13	2.95	3.68	20.28	0.00	0.00	0.00	0.00	41.33
2012	0.00	0.07	0.00	0.00	0.00	0.00	0.26	0.00	0.34	12.63	0.15	0.00	0.00	0.15	16.60	0.18	1.97	0.00	2.15	41.33
2013	0.07	5.45	1.26	0.24	1.10	1.29	1.39	1.50	12.29	12.29	11.14	2.24	3.07	16.45	16.45	8.00	1.97	11.93	21.90	39.18
2014	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.80	2.24	4.04	17.29
2015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.66	0.00	0.66	13.25
2016	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.27	9.17	0.15	12.59	12.59

In contrast, in the 2016/17 cropping season, the most recent varieties were cultivated by lesser number of farmers where only 41.33% of Uzbek wheat growers cultivated varieties that were five years old or under, while 81% of farmers cultivated varieties 10 years old or under. Only 2.9% of growers were cultivating varieties that were 20 or more years old – showing Uzbekistan has made clear progress in replacing obsolete wheat varieties.

6.6.2.4 Adoption rate – by farm types (Dehkan and Fermers)

While there were a mix of fermers (large farms) and dehkan (smallholder farmers) in the sample of farmers surveyed in 2012/2013, all sample farmers in 2016/17 were only Fermers. In 2012/2013, Karakalpakstan led all provinces in terms of the percentage of dehkan farmers adopting recent wheat varieties (Table 6.14). All the dehkan farmers in this province cultivated varieties that were 10 years old or under, followed by Samarkand (93.8%), Qashqadarya (91%) and Jizzakh (85%). When it comes to old varieties, 47.6% of dehkan farmers in Tashkent province were still cultivating varieties which were over 20 years old, followed by Andijan (22.2%) and Qashqadarya (9%).

Table 6.14. Percentage of smallholders (Dehkan) who planted wheat varieties from different release dates in 2012/2013 – by Province

	All 8 provinces (2012/13 cropping season)								Only the three revisited provinces (2012/13 cropping season)		
Released in or after this year	Karakalpakstan	Andijan	Bukhara	Jizzakh	Qashqadarya	Navoi	Samarkand	Tashkent	Andijan	Qashqadarya	Tashkent
1900	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1953	100.00	100.00	100.00	100.00	100.00	100.00	100.00	76.83	100.00	100.00	76.83
1980	100.00	100.00	100.00	100.00	96.15	100.00	100.00	76.83	100.00	96.15	76.83
1981	100.00	100.00	100.00	100.00	96.15	100.00	100.00	52.44	100.00	96.15	52.44
1993	100.00	100.00	100.00	100.00	91.03	100.00	100.00	52.44	100.00	91.03	52.44
1995	100.00	77.78	95.00	100.00	91.03	100.00	100.00	52.44	77.78	91.03	52.44
1999	100.00	77.78	95.00	100.00	91.03	100.00	100.00	52.44	77.78	91.03	52.44
2000	100.00	75.93	95.00	100.00	91.03	100.00	98.44	52.44	75.93	91.03	52.44
2001	100.00	61.11	91.67	91.30	91.03	50.00	93.75	52.44	61.11	91.03	52.44
2002	100.00	61.11	91.67	91.30	91.03	50.00	93.75	52.44	61.11	91.03	52.44
2003	100.00	61.11	86.67	91.30	91.03	50.00	93.75	52.44	61.11	91.03	52.44
2004	100.00	53.70	68.33	84.78	91.03	50.00	93.75	52.44	53.70	91.03	52.44
2005	100.00	53.70	65.00	84.78	91.03	50.00	50.00	52.44	53.70	91.03	52.44
2006	100.00	53.70	65.00	84.78	91.03	50.00	50.00	52.44	53.70	91.03	52.44
2007	91.30	50.00	60.00	84.78	91.03	50.00	50.00	52.44	50.00	91.03	52.44
2008	91.30	50.00	60.00	84.78	80.77	50.00	50.00	52.44	50.00	80.77	52.44
2010	91.30	50.00	60.00	76.09	67.95	50.00	9.38	26.83	50.00	67.95	26.83
2011	0.00	18.52	3.33	4.35	1.28	12.50	1.56	14.63	18.52	1.28	14.63
2012	0.00	18.52	3.33	4.35	1.28	12.50	1.56	13.41	18.52	1.28	13.41
2013	0.00	18.52	3.33	4.35	1.28	12.50	1.56	13.41	18.52	1.28	13.41

At national level, the number of dehkan farmers cultivating improved wheat varieties of five years old or under accounted for 62.8% of the total national number of dehkan wheat growers. While the figure increased when the cutoff point increases to 10 years (74.1%), it is evident that only 10% of the total national number of dehkan wheat growers were still cultivating varieties which were older than 20 years (Table 6.15).

Table 6.15. Percentage of smallholders (Dehkan) who planted wheat varieties of different release dates in 2012/13 – national figures (Adoption rates are generated by using number of growers in each province as weights)

	All 8 provinces (2012/13 cropping season)									Only the three revisited Provinces (2012/13 cropping season)			
Released in this specific year	Karakalpakstan	Andijan	Bukhara	Jizzakh	Qashadarya	Navoi	Samarkand	Tashkent	Total	Cumulative	Andijan	Qashadarya	Tashkent	Total	Cumulative
1900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.05	4.05	100.00	0.00	0.00	7.98	7.98	100.00
1953	0.00	0.00	0.00	0.00	0.72	0.00	0.00	0.00	0.72	95.95	0.00	1.41	0.00	1.41	92.02
1980	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.27	4.27	95.23	0.00	0.00	8.40	8.40	90.61
1981	0.00	0.00	0.00	0.00	0.95	0.00	0.00	0.00	0.95	90.97	0.00	1.88	0.00	1.88	82.22
1993	0.00	3.27	0.93	0.00	0.00	0.00	0.00	0.00	4.19	90.01	6.43	0.00	0.00	6.43	80.34
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	85.82	0.00	0.00	0.00	0.00	73.91
1999	0.00	0.27	0.00	0.00	0.00	0.00	0.24	0.00	0.52	85.82	0.54	0.00	0.00	0.54	73.91
2000	0.00	2.18	0.62	0.60	0.00	1.12	0.73	0.00	5.25	85.30	4.28	0.00	0.00	4.28	73.38
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	80.05	0.00	0.00	0.00	0.00	69.09
2002	0.00	0.00	0.93	0.00	0.00	0.00	0.00	0.00	0.93	80.05	0.00	0.00	0.00	0.00	69.09
2003	0.00	1.09	3.40	0.45	0.00	0.00	0.00	0.00	4.94	79.12	2.14	0.00	0.00	2.14	69.09
2004	0.00	0.00	0.62	0.00	0.00	0.00	6.86	0.00	7.47	74.18	0.00	0.00	0.00	0.00	66.95
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	66.71	0.00	0.00	0.00	0.00	66.95
2006	0.51	0.54	0.93	0.00	0.00	0.00	0.00	0.00	1.98	66.71	1.07	0.00	0.00	1.07	66.95
2007	0.00	0.00	0.00	0.00	1.91	0.00	0.00	0.00	1.91	64.73	0.00	3.76	0.00	3.76	65.88
2008	0.00	0.00	0.00	0.60	2.39	0.00	6.37	4.48	13.83	62.82	0.00	4.70	8.82	13.51	62.12
2010	5.32	4.63	10.52	4.94	12.41	0.84	1.22	2.13	42.02	48.99	9.11	24.44	4.20	37.74	48.60
2011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.21	6.96	0.00	0.00	0.42	0.42	10.86
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.75	0.00	0.00	0.00	0.00	10.44
2013	0.00	2.72	0.62	0.30	0.24	0.28	0.24	2.35	6.75	6.75	5.36	0.47	4.62	10.44	10.44
Total (% share of total national number of growers)	5.83	14.69	18.56	6.89	18.62	2.24	15.67	17.49	100.00		28.92	36.65	34.42	100.00	

Samarkand led all provinces in terms of the percentage of fermers adopting recent wheat varieties (Table 6.16). About 93.1% of the fermers in this province cultivated varieties which were 10 years old or under, followed by Tashkent (90.1%), and Andijan (88.8%). In terms of very old varieties, Tashkent led nationally with 5% of fermers in the province cultivating varieties 20 years old or over, followed by Andijan (2.8%), and Qashqadarya (2.8%)

Table 6.16. Cumulative percentage of large farms (fermers) who cultivated wheat varieties released in specific years or later during the 2012/13 survey – by province

	All 8 provinces (2012/13 cropping season)								Only the three revisited provinces (2012/13 cropping season)			Only the three revisited provinces (2016/17 cropping season)		
Released in or after this year	Karakalpakstan	Andijan	Bukhara	Jizzakh	Qashqadarya	Navoi	Samarkand	Tashkent	Andijan	Qashqadarya	Tashkent	Andijan	Qashqadarya	Tashkent
1900	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1953	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1980	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1981	100.00	97.19	100.00	100.00	100.00	100.00	100.00	95.03	97.19	100.00	95.03	100.00	97.12	99.52
1983	100.00	97.19	100.00	100.00	97.22	100.00	100.00	95.03	97.19	97.22	95.03	100.00	96.15	99.52
1990	100.00	97.19	100.00	100.00	97.22	100.00	100.00	95.03	97.19	97.22	95.03	100.00	92.79	99.04
1991	100.00	97.19	100.00	100.00	97.22	100.00	100.00	95.03	97.19	97.22	95.03	100.00	92.79	98.56
1993	100.00	97.19	100.00	100.00	97.22	100.00	100.00	95.03	97.19	97.22	95.03	100.00	92.79	98.56
1995	100.00	96.63	96.97	100.00	97.22	100.00	100.00	93.92	96.63	97.22	93.92	100.00	92.79	98.56
1999	94.44	96.63	96.97	100.00	97.22	98.44	100.00	93.92	96.63	97.22	93.92	100.00	92.79	98.08
2000	94.44	95.51	96.97	100.00	95.00	98.44	98.61	92.27	95.51	95.00	92.27	100.00	89.90	97.12
2001	92.22	92.70	91.92	88.35	91.11	98.44	93.06	90.61	92.70	91.11	90.61	98.44	89.90	87.50
2002	91.11	91.01	91.92	88.35	89.44	98.44	93.06	90.06	91.01	89.44	90.06	98.44	88.94	87.02
2003	91.11	88.76	91.92	85.44	81.67	84.38	93.06	90.06	88.76	81.67	90.06	92.71	87.98	87.02
2004	75.56	88.76	81.82	74.76	81.67	84.38	93.06	90.06	88.76	81.67	90.06	92.19	87.98	87.02
2005	75.56	85.96	81.82	74.76	81.11	81.25	84.26	90.06	85.96	81.11	90.06	80.73	87.50	87.02
2006	75.56	85.96	81.82	74.76	81.11	81.25	84.26	87.85	85.96	81.11	87.85	80.73	87.50	87.02
2007	73.33	83.15	77.78	70.87	81.11	81.25	83.80	82.87	83.15	81.11	82.87	78.13	79.33	86.06
2008	73.33	83.15	77.78	70.87	77.78	81.25	83.33	82.87	83.15	77.78	82.87	77.60	79.33	85.10
2009	71.11	72.47	74.75	69.90	61.11	71.88	36.11	67.96	72.47	61.11	67.96	38.54	70.67	72.12
2010	71.11	72.47	74.75	69.90	61.11	71.88	36.11	67.96	72.47	61.11	67.96	38.54	70.19	71.15
2011	1.11	38.76	13.13	3.88	9.44	62.50	11.11	21.55	38.76	9.44	21.55	32.81	45.67	46.15
2012	1.11	36.52	13.13	3.88	8.89	25.00	11.11	8.29	36.52	8.89	8.29	32.81	45.67	46.15
2013	1.11	35.96	13.13	3.88	8.89	25.00	9.26	8.29	35.96	8.89	8.29	32.29	39.90	46.15
2014	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.38	34.13	7.69
2015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.38	28.85	0.48
2016	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.38	26.92	0.48

The national figures for fermers showed adoption rates of improved wheat varieties released within the previous five years were lower (62.8%) than those of dehkan (67.4%). However, when the cut-off points are increased 86.8% and 96.02% of fermers and 74.18% and 90.01% of dehkans, respectively were cultivating 10 years or under and 20 years old or more varieties. These results show that while there were higher adoption rates among dehkans for most recent (less than five years old) varieties, fermers have generally higher adoption rates when the cut-off point is increased. However, only 1.7% of fermers were still cultivating varieties more than 20 years old (Table 6.17).

Table 6.17. Percentage of large farms (fermers) who planted durum wheat varieties from different release dates during the 2012/2013 survey – national figures (adoption rates are generated by using number of growers in each province as weights)

	All 8 provinces (2012/13 cropping season)										Only the three revisited provinces (2012/13 cropping season)						Only the three revisited provinces (2016/17 cropping season)					
Released in or after this year	Karakalpakstan	Andijan	Bukhara	Jizzakh	Qashqadarya	Navoi	Samarkand	Tashkent	Total	Cumulative	Andijan	Qashqadarya	Tashkent	Total	Cumulative	Andijan	Qashqadarya	Tashkent	Total	Cumulative
1900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	100.00
1953	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	100.00
1980	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.71	1.22	100.00	1.05	0.00	1.48	2.52	100.00	0.00	0.98	0.15	1.13	100.00
1981	0.00	0.00	0.00	0.00	0.44	0.00	0.00	0.00	0.44	98.78	0.00	0.92	0.00	0.92	97.48	0.00	0.33	0.00	0.33	98.87
1983	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	98.34	0.00	0.00	0.00	0.00	96.56	0.00	0.00	0.15	0.15	98.54
1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	98.34	0.00	0.00	0.00	0.00	96.56	0.00	1.15	0.00	1.15	98.39
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	98.34	0.00	0.00	0.00	0.00	96.56	0.00	0.00	0.15	0.15	97.25
1993	0.00	0.10	0.34	0.00	0.00	0.00	0.00	0.16	0.60	98.34	0.21	0.00	0.33	0.54	96.56	0.00	0.00	0.00	0.00	97.10
1995	0.47	0.00	0.00	0.00	0.00	0.10	0.00	0.0	0.57	97.74	0.00	0.00	0.0	0.00	96.02	0.00	0.00	0.15	0.15	97.10
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.07	97.16	0.00	1.00	0.00	1.65	96.02	0.00	0.98	0.30	1.28	96.95
2000	0.19	0.50	0.57	0.67	0.62	0.00	1.00	0.00	3.88	96.10	1.05	1.29	0.00	2.82	94.38	0.55	0.00	2.98	3.53	95.67
2001	0.09	0.30	0.00	0.00	0.27	0.00	0.00	0.08	0.74	92.22	0.63	0.55	0.16	1.34	91.55	0.00	0.33	0.15	0.48	92.14
2002	0.00	0.40	0.00	0.17	1.24	0.94	0.00	0.00	2.75	91.48	0.84	2.57	0.00	3.41	90.21	2.00	0.33	0.00	2.33	91.66
2003	1.32	0.00	1.15	0.61	0.00	0.00	0.00	0.00	3.07	88.73	0.00	0.00	0.00	0.00	86.80	0.18	0.00	0.00	0.18	89.33
2004	0.00	1.00	0.00	0.00	0.00	0.00	2.00	0.00	2.53	85.66	1.00	0.00	0.00	1.23	86.80	4.00	0.16	0.00	4.16	89.15
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.32	83.13	0.00	0.00	0.66	0.66	85.57	0.00	0.00	0.00	0.00	84.99
2006	0.19	0.50	0.00	0.00	0.00	0.00	0.00	0.71	2.18	82.82	1.05	0.00	1.48	2.52	84.92	0.91	2.78	0.30	3.99	84.99
2007	0.00	0.00	0.00	0.00	0.53	0.00	0.09	0.00	0.62	80.64	0.00	1.10	0.00	1.10	82.39	0.18	0.00	0.30	0.48	81.00
2008	0.19	1.92	0.00	0.00	2.66	0.62	9.26	2.13	17.18	80.02	3.98	5.51	4.43	13.91	81.29	13.64	2.95	4.03	20.61	80.52
2009	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	62.84	0.00	0.00	0.00	0.00	67.38	0.00	0.16	0.30	0.46	59.90
2010	5.92	6.05	7.00	4.00	8.23	0.62	4.90	6.64	43.15	62.84	12.56	17.08	13.78	43.41	67.38	2.00	8.35	7.75	18.11	59.44
2011	0.00	0.40	0.00	0.00	0.00	2.50	0.00	1.90	4.89	19.70	0.84	0.00	3.94	4.96	23.96	0.00	0.00	0.00	0.00	41.33
2012	0.00	0.10	0.00	0.00	0.00	0.00	0.36	0.00	0.46	14.81	0.21	0.00	0.00	0.21	19.00	0.18	1.97	0.00	2.15	41.33
2013	0.09	6.46	1.49	0.00	1.00	1.66	1.82	1.19	14.35	14.35	13.40	3.00	2.46	18.79	18.79	8.00	1.97	11.93	21.90	39.18
2014	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.80	2.24	4.04	17.29
2015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.66	0.00	0.66	13.25
2016	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.27	9.17	0.15	12.59	12.59

6.6.2.5 Adoption degree by variety (percentage of wheat area under improved varieties)

Based on the 2012/13 data, the top 10 of the 41 distinct wheat varieties found in the Uzbek farmers' hands covered more than 81% of total area. This is almost the same as the adoption rate of 80% for the top 10 varieties presented in Section 6.5.2.1. This shows that there is no systematic difference between large and small farmers regarding adoption of improved wheat varieties. However, only six of the top 10 varieties were released after 2006, showing that old varieties were still being cultivated in Uzbekistan. The area coverage of the top 10 varieties during 2012/13 in only the three revisited provinces was 84.3%. The top two varieties by area in all eight provinces are Tanya and Krasnodarskaya99. Together, these two constituted over 47.3% of total national wheat area.

In the 2016/17 cropping season, the top 10 of the 39 distinct wheat varieties found in farmers' hands covered more than 80.8% of total wheat area in the three revisited provinces. While the dominance of fewer varieties is concerning, eight of the top 10 varieties were released after 2006. This shows a clear improvement in varietal replacement rate since 2012/2013 in the three revisited provinces and that new varieties dominated the wheat fields. In 2016/2017, the top two varieties by area were Krasnodarskaya99 (released in 2008) and Grom (released in 2013). Together, the two varieties constituted over 36.8 % of total national wheat area in the three revisited provinces (Table 6.18). This indicates that fewer but larger farmers (fermers) are cultivating Krasnodarskaya99 while a lot of small farmers are cultivating Tanya.

Table 6.18. Adoption degree (% of area) by variety

All 8 provinces (2012/13 cropping season)					Only the three revisited provinces (2012/13 cropping season)					Only the three revisited provinces (2016/17 cropping season)			
Adoption degree rank	Variety name	YYear of release	Adoption degree (% of area)	Cumulative	Variety name	Yyear of release	Adoption degree (% of area %)	Cumulative degree of adoption (%)		Variety name	YYear of release	Adoption degree (% of area)	Cumulative degree of adoption (%)
1	Tanya	2010	26.32	26.32	Tanya	2010	29.13	29.13		Krasnodarskaya99	2008	18.99	18.99
2	Krasnodarskaya99	2008	21.03	47.35	Bobur	2013	16.01	45.15		Grom	2013	17.80	36.79
3	Bobur	2013	12.01	59.36	Krasnodarskaya99	2008	13.21	58.35		Tanya	2010	14.61	51.40
4	Esaul	2011	5.26	64.62	Tezpishar	1980	7.04	65.40		Andija 4	2004	6.50	57.90
5	Kroshka	2000	3.43	68.04	Esaul	2011	4.78	70.18		G'ozg'on	2016	4.99	62.88
6	Tezpishar	1980	3.25	71.29	Moskvich	2010	4.44	74.62		Vassa	2016	4.53	67.41
7	Nota	2010	2.78	74.08	Chillaki	2002	3.34	77.95		Bobur	2006	4.40	71.81
8	Moskvich	2010	2.63	76.71	Nota	2010	2.39	80.35		Gratsiya	2013	3.02	74.83
9	Chillaki	2002	2.50	79.21	Andijan1	2008	2.12	82.47		Kroshka	2000	3.00	77.83
10	Andija 4	2004	2.13	81.34	Kokbulak	2001	1.91	84.38		Yaksart	2014	2.98	80.81
11	Andijan2	2003	2.02	83.36	Vostorg	2010	1.50	85.88		Chillaki	2002	2.02	82.83
12	Starshina	2004	1.54	84.90	Andija 4	2004	1.46	87.33		Andijan1	2008	1.89	84.72
13	Vostorg	2010	1.31	86.22	Kroshka	2000	1.43	88.76		Hazrati bashir	2016	1.79	86.51
14	Mars1	2006	1.14	87.36	Mars1	2006	1.29	90.05		ASR	2013	1.65	88.15
15	Yaksart	2014	1.08	88.44	Selyanka Odesskaya	2006	1.08	91.13		Matonat	2012	1.41	89.57
16	Andijan1	2008	1.07	89.51	Kupava	1999	1.04	92.17		Lebed	2016	1.36	90.92
17	Polovchanka	1999	1.00	90.51	Intensivnaya	1981	0.79	92.96		Kupava	1999	1.32	92.24
18	Fortuna	2012	0.98	91.49	Krasnovodopadskaya210	1980	0.78	93.74		Sanzar4	1990	1.22	93.46
19	Kokbulak	2001	0.88	92.37	Oq Bugdoy	1993	0.77	94.51		Tezpishar	1980	1.19	94.65
20	Turaqurgon_1l	2010	0.78	93.15	Gratsiya	2013	0.74	95.26		Vostorg	2010	0.64	95.28
21	ASR	2013	0.77	93.92	Fortuna	2012	0.67	95.92		Muftallo	2015	0.60	95.88
22	Oq Bugdoy	1993	0.74	94.66	Dustlik	2005	0.60	96.52		Zvezda	2016	0.54	96.42
23	Nikoniya	2006	0.61	95.27	Jayhun_Zamin1	2007	0.55	97.08		Yanbosh	1995	0.42	96.84
24	Selyanka Odesskaya	2006	0.57	95.84	Rapsodia	2013	0.49	97.56		Zemnitsa	2016	0.40	97.24
25	Umanka	2000	0.53	96.36	Turaqurgon_1l	2010	0.49	98.05		Durdona	2009	0.35	97.58
26	Gratsiya	2013	0.51	96.87	Polovchanka	1999	0.45	98.50		Semurg	2010	0.33	97.91
27	Kupava	1999	0.48	97.35	Kuma	2010	0.38	98.88		Jayhun_Zamin1	2007	0.32	98.23

All 8 provinces (2012/13 cropping season)					Only the three revisited provinces (2012/13 cropping season)				Only the three revisited provinces (2016/17 cropping season)			
Adop-tion degree rank	Variety name	YYear of release	Adoption degree (% of area)	Cumula-tive	Variety name	Yyear of re-lease	Adoption degree (% of area %)	Cumulative degree of adoption (%)	Variety name	YYear of re-lease	Adoption degree (% of area)	Cumulative degree of adoption (%)
28	Grom	2013	0.46	97.81	Umanka	2000	0.35	99.24	Bahmal97	2012	0.25	98.47
29	Intensivnaya	1981	0.37	98.17	Nikoniya	2006	0.29	99.53	Andijan2	2003	0.22	98.70
30	Jayhun_Zamin1	2007	0.37	98.54	Turkiston	2011	0.19	99.72	Moskvich	2010	0.22	98.92
31	Krasnovodopadskaya210	1980	0.36	98.90	Sanzar 6	1999	0.12	99.84	Yuka	2016	0.22	99.14
32	Dustlik	2005	0.28	99.18	Yaksart	2014	0.10	99.94	Kokbulak	2001	0.19	99.33
33	Rapsodia	2013	0.23	99.40	Elita	1900	0.03	99.97	Zumrad	2001	0.19	99.52
34	Yanbosh	1995	0.21	99.62	Knyajna	2000	0.01	99.98	Omad	2012	0.17	99.69
35	Kuma	2010	0.18	99.79	Surkhon	1953	0.01	99.99	Bunyodkor	2016	0.16	99.84
36	Turkiston	2011	0.09	99.88	Andijan2	2003	0.01	99.997	Intensivnaya	1981	0.07	99.92
37	Sanzar 6	1999	0.06	99.94	Grom	2013	0.00	100.00	Grekum439	1983	0.03	99.95
38	Zumrad	2001	0.04	99.98					Krasnovodopadskaya210	1980	0.03	99.98
39	Elita	1900	0.01	99.99					Sanzar 6	1991	0.02	100.00
40	Knyajna	2000	0.01	99.996								
41	Surkhon	1953	0.00	100.00								
	Total		100									

Note: the entries highlighted in gray color represent rust-resistant varieties originated from IWWIP – a joint Turkey-CIMMIYT-ICARDA Program based in Turkey. Out of four varieties released in Uzbekistan, three (G'ozg'on, Yaksart, and Bunyodkor) cover 8.13% of total wheat area in the three revisited provinces. The fourth variety (Shams) wasn't found in farmers' hands.

6.6.2.6 Adoption degree by province

In 2012/13, with an adoption degree of 89.2% (of total wheat area) for improved wheat varieties which were at least 10 years old at the time, Samarkand led all provinces. Navoi and Andijan followed, with corresponding figures of 86.8% and 85.5%, respectively. Tashkent was the province with the highest (14.5%) share of more than 20 years old varieties followed by Andijan at 6.6% (Table 6.19). Considering the three revisited provinces only, the average adoption degree of wheat varieties which were 10 years old or under at the time was 80.4%. Of the three, Andijan had the highest (85.6%) adoption degree for varieties which were 10 years old or less at the time, while Tashkent had the highest (14.5%) adoption degree for varieties that were 20 years old or more.

In the 2016/17 cropping season, adoption degree for newly released varieties was the highest in Tashkent with 55.1% of farmers cultivating varieties that were less than five years old (i.e., varieties released after 2013). For 10 years old and under varieties (i.e., those released after 2006), Tashkent was leading the group at adoption degree of 86.4. This is similar to the adoption rate by province in Section 6.6.2.2. It is also further evidence for the absence of systematic bias in adoption by farm size. With an additional adoption of 4.65% for varieties of 10 years old and under, Tashkent exhibited the highest gain in adoption among the three revisited provinces between 2012/13 and 2016/2017 while the other two have seen reduction during this period.

Table 6.19. Cumulative percentage of wheat area under wheat varieties released in specific years or later (adoption degree) –by province

Released in or after this year	All 8 provinces (2012/13 cropping season)								Only the three revisited provinces (2012/13 cropping season)			Only the three revisited provinces (2016/17 cropping season)		
	Karakalpakstan	Andijan	Bukhara	Jizzakh	Qashqadarya	Navoi	Samarkand	Tashkent	Ndijan	Qashqadarya	Tashken	ndijan	Qashqadarya	Tashken
1900	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1953	100.00	100.00	100.00	100.00	100.00	1000	1000	99.92	100.00	100.00	99.92	100.00	100.00	100.00
1980	100.00	100.00	100.00	100.00	99.97	100.00	100.00	99.92	100.00	99.97	99.92	100.00	100.00	100.00
1981	100.00	93.34	100.00	100.00	99.97	100.00	100.00	85.45	93.34	99.97	85.45	100.00	96.31	99.88
1983	100.00	93.34	100.00	100.00	97.11	100.00	100.00	85.45	93.34	97.11	85.45	100.00	96.08	99.88
1990	100.00	93.34	100.00	100.00	97.11	100.00	100.00	85.45	93.34	97.11	85.45	100.00	96.08	99.76
1991	100.00	93.34	100.00	100.00	97.11	100.00	100.00	85.45	93.34	97.11	85.45	100.00	92.28	99.76
1993	100.00	93.34	100.00	100.00	97.11	100.00	100.00	85.45	93.34	97.11	85.45	100.00	92.28	99.68
1995	100.00	92.70	93.12	100.00	97.11	100.00	100.00	84.02	92.70	97.11	84.02	100.00	92.28	99.68
1999	97.53	92.70	93.12	100.00	97.11	98.71	100.00	84.02	92.70	97.11	84.02	100.00	92.28	98.10
2000	97.53	89.61	93.12	100.00	96.25	98.71	97.49	83.17	89.61	96.25	83.17	100.00	89.37	96.67
2001	94.96	88.03	92.70	91.01	92.80	98.71	89.21	82.38	88.03	92.80	82.38	98.78	89.37	87.26
2002	94.17	86.52	92.70	91.01	88.68	98.71	89.21	81.71	86.52	88.68	81.71	98.78	88.58	86.78
2003	94.17	85.56	92.68	90.70	77.81	86.86	89.21	81.71	85.56	77.81	81.71	94.80	87.41	86.78
2004	76.60	85.55	79.66	78.96	77.81	86.86	89.21	81.71	85.55	77.81	81.71	94.26	87.41	86.78
2005	76.60	81.58	79.64	78.96	77.36	84.96	80.16	81.71	81.58	77.36	81.71	78.74	87.15	86.78
2006	76.60	81.58	79.64	78.96	77.36	84.96	80.16	80.15	81.58	77.36	80.15	78.74	87.15	86.78
2007	73.68	79.67	68.09	73.25	77.36	84.96	79.93	74.94	79.67	77.36	74.94	76.54	76.65	86.36
2008	73.68	79.67	68.09	73.25	75.38	84.96	79.58	74.94	79.67	75.38	74.94	76.16	76.65	85.75
2009	71.51	66.93	64.88	73.12	48.04	79.75	34.12	66.00	66.93	48.04	66.00	34.33	70.66	79.51
2010	71.51	66.93	64.88	73.12	48.04	79.75	34.12	66.00	66.93	48.04	66.00	34.33	70.23	78.72
2011	1.68	32.20	16.21	4.93	14.73	73.92	11.61	20.91	32.20	14.73	20.91	29.37	46.97	55.10
2012	1.68	29.86	16.21	4.93	14.35	35.69	11.61	10.36	29.86	14.35	10.36	29.37	46.97	55.10
2013	1.68	27.87	16.21	4.93	14.35	35.69	9.49	10.36	27.87	14.35	10.36	28.77	42.06	55.10
2014	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.34	36.82	6.95
2015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.34	33.09	0.23
2016	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.34	31.23	0.23

6.6.2.7 Adoption degree (% of area) – national level

In 2012/13, wheat production in Uzbekistan was generally characterized by the dominance of new varieties, where 82% of total national wheat area was covered by varieties which were under 10 years old. However, the figure reduces to 57.8% when the cut-off year is reduced by five years, which is still high by any standards. Only 3.1% of total national wheat area was under improved wheat varieties that were 20 or more years old. Considering only the three revisited provinces, the cumulative average adoption degree for varieties which were five, 10, and 20-year-old and under at the time were 56.8%, 80.4%, and 93.0%, respectively, of the three provinces' total wheat area (Table 6.20).

In the 2016/17 cropping season, area under varieties of age 10 years and under was 79.2%, which is slightly lower than it was in 2012/2013. Only 2.5% of the growers were still cultivating varieties released before 20 years. Comparing between 2012/13 and 2016/17 the adoption degree for 20-year-old varieties and under in the three revisited provinces had increased by 4.4%–evidence for improvement in the replacement of obsolete varieties.

Table 6.20. Percentage of wheat area under varieties of different release dates – national figures (adoption degrees are generated by using wheat areas in each of the provinces as weights)

	All 8 provinces (2012/13 cropping season)											Only the three revisited provinces (2012/13 cropping season)							Only the three revisited provinces (2016/17 cropping season)						
Released in or after this year	Karakalpakstan	Andijan	Bukhara	Jizzakh	Qashqadarya	Navoi	Samarkand	Tashkent	Total	Cumulative		Andijan	Qashqadarya	Tashkent	Total	Cumulative		Andijan	Qashqadarya	Tashkent	Total	Cumulative	
1900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	100.00		0.00	0.00	0.02	0.02	1000		0.00	0.00	0.00	0.00	100.00	
1953	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	99.99		0.00	0.02	0.00	0.02	99.98		0.00	0.00	0.00	0.00	100.00	
1980	0.00	0.57	0.00	0.00	0.00	0.00	0.00	1.88	2.45	99.98		1.27	0.00	4.16	5.43	99.96		0.00	1.83	0.04	1.22	100.00	
1981	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.67	97.54		0.00	1.49	0.00	1.49	94.54		0.00	0.11	0.00	0.07	98.78	
1983	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	96.86		0.00	0.00	0.00	0.00	93.04		0.00	0.00	0.04	0.03	98.71	
1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	96.86		0.00	0.00	0.00	0.00	93.04		0.00	1.88	0.00	1.22	98.68	
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	96.86		0.00	0.00	0.00	0.00	93.04		0.00	0.00	0.03	0.02	97.45	
1993	0.00	0.05	0.39	0.00	0.00	0.00	0.00	0.19	0.63	96.86		0.12	0.00	0.41	0.53	93.04		0.00	0.00	0.00	0.00	97.43	
1995	0.14	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.22	96.23		0.00	0.00	0.00	0.00	92.51		0.00	0.00	0.50	0.42	97.43	
1999	0.00	0.27	0.00	0.00	0.20	0.00	0.50	0.11	1.08	96.01		0.59	0.45	0.25	1.29	92.51		0.00	1.44	0.45	1.32	97.01	
2000	0.15	0.14	0.02	1.58	0.81	0.00	1.65	0.10	4.45	94.93		0.30	1.80	0.23	2.33	91.23		0.23	0.00	2.99	3.00	95.70	
2001	0.05	0.13	0.00	0.00	0.97	0.00	0.00	0.09	1.23	90.48		0.29	2.15	0.19	2.63	88.89		0.00	0.39	0.15	0.38	92.70	
2002	0.00	0.08	0.00	0.06	2.56	0.70	0.00	0.00	3.40	89.25		0.18	5.67	0.00	5.85	86.26		0.75	0.58	0.00	2.02	92.32	
2003	1.03	0.00	0.74	2.06	0.00	0.00	0.00	0.00	3.83	85.85		0.00	0.00	0.00	0.00	80.41		0.10	0.00	0.00	0.22	90.30	
2004	0.00	0.34	0.00	0.00	0.11	0.11	1.80	0.00	2.36	82.02		0.75	0.23	0.00	0.99	80.40		2.90	0.13	0.00	6.50	90.08	
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.20	79.66		0.00	0.00	0.45	0.45	79.42		0.00	0.00	0.00	0.00	83.58	
2006	0.17	0.16	0.66	1.00	0.00	0.00	0.05	0.68	2.71	79.46		0.36	0.00	1.50	1.86	78.97		0.41	5.20	0.13	4.40	83.58	
2007	0.00	0.00	0.00	0.00	0.47	0.00	0.07	0.00	0.54	76.74		0.00	1.04	0.00	1.04	77.11		0.07	0.00	0.20	0.32	79.18	
2008	0.13	1.09	0.18	0.02	6.44	0.31	9.06	1.16	18.39	76.21		2.42	14.28	2.57	19.27	76.07		7.83	2.97	1.98	20.88	78.86	
2009	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	57.82		0.00	0.00	0.00	0.00	56.79		0.00	0.21	0.25	0.35	57.98	
2010	4.10	2.98	2.76	11.96	7.84	0.34	4.49	5.84	40.32	57.82		6.61	17.39	12.96	36.96	56.79		0.93	11.52	7.50	15.79	57.64	
2011	0.00	0.20	0.00	0.00	0.09	2.26	0.00	1.37	3.91	17.50		0.45	0.20	3.03	3.68	19.83		0.00	0.00	0.00	0.00	41.85	
2012	0.00	0.17	0.00	0.00	0.00	0.00	0.42	0.00	0.59	13.59		0.38	0.00	0.00	0.38	16.15		0.11	2.43	0.00	1.83	41.85	
2013	0.10	2.39	0.92	0.86	3.38	2.11	1.89	1.34	12.99	12.99		5.30	7.49	2.98	15.77	15.77		3.64	2.59	15.29	22.47	40.02	
2014	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.00	1.85	2.13	2.98	17.55	
2015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		0.00	0.92	0.00	0.60	14.57	
2016	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00		1.75	15.47	0.07	13.97	13.97	

6.6.2.8 Factors affecting farmers' decisions and intensity of adoption

Looking at the adoption rates reported in section 6.6.2.2, in 2012/13, 82.6 % of farmers adopted varieties of 10 years old or under (i.e., varieties released in, or after, 2004). These varieties were cultivated on 82% of total wheat area. The corresponding adoption figures for 2012/13 only for the three revisited provinces were 81% of farmers and 80.4% of total wheat area. In the 2016/17 cropping season, 81% of total growers in the three revisited provinces cultivated varieties that were under 10 years old at the time (i.e., those released in, or after, 2007) on 79.2% of the total wheat area in the three provinces.

To see if the importance of variables in influencing farmers' adoption decision changed over time, we carried out two regression analyses using the two datasets (i.e., data from the 2012/13 and 2016/17 surveys), separately for the three revisited provinces. Parameter estimates for the Double Hurdle (DH) model are provided in Table 6.21 below. Model results show that in both 2012/13 and 2016/17, the total crop land cultivated positively and significantly affected farmers' decisions on whether to adopt improved wheat varieties or not which also agrees with the higher adoption level for 10 or less old varieties among fermers who normally cultivate larger areas than the smallholder dehkans. This result is also consistent with other past studies from Morocco (Yigezu et al., 2019b), Mozambique (Uaiene et al., 2009), which found farmers with large farm sizes are likely to adopt a new technology including improved varieties. Theoretically also, one would expect larger farms (often commercial) to find it worth investing in improved varieties with higher yields, unlike smallholders who usually prefer traditional varieties with specific quality traits (such as color, suitability for traditional bread making and other baking qualities) important for own-home consumption.

Years in education for the household head and access to credit also positively and significantly affected the decision to adopt in both survey years. These results are valid as educated farmers are likely to better understand the benefits and also have the knowledge and skills to better manage new technology packages such as wheat and other associated management practices including fertilization. It is also consistent with the findings of other studies (Ullah et al., 2014; Leake and Adam, 2015; Kebede et al., 2016; Mirani et al., 2002). Farmers with better access to credit are also likely to adopt new varieties as they'll have the financial liquidity to buy certified seeds and other complementary inputs such as fertilizers, herbicides, pesticides, and any extra labor needed. This is also consistent with findings of other studies (Kudama, 2021; Milkias, 2020; Tura et al., 2010; Odoemenem and Obinne 2010; Wondale et al., 2016; Chandio and Jiang, 2018).

Table 6.21. Parameter estimates of the Double Hurdle (DH) model for using improved varieties

Variables	Only the three revisited provinces (2012/13 cropping season)				Only the three revisited provinces (2016/17 cropping season)			
	Outcome equations		Selection equation		Outcome equations		Selection equation	
	Area under the new varieties		Adoption dummy		Area under the new varieties		Adoption dummy	
	Coef.	Std.Er.	Coef.	Std.Er.	Coef.	Std.Er.	Coef.	Std.Er.
Age (Years)	0.133	0.132	0.122	0.283	-0.165	0.127	0.095	0.24
Sex {1=Male, 0=Female}	-0.15	0.105	-0.04	0.201	-0.246	0.162	0.384	0.278
Number of years in education	0.002	0.059	0.807	0.129***	-0.024	0.06	0.383	0.123***
Get a credit from a bank {1=yes, 0=No}	-0.22	0.079***	0.961	0.161***	0.063	0.071	0.368	0.129***
Off-farm employment {1=yes, 0=No}	0.345	0.066***	0.099	0.152	0.103	0.069	-0.073	0.143
Irrigated {1=yes, 0=No}	-0.259	0.107***	0.52	0.173***	-0.185	0.116*	0.026	0.263
Wheat area (Ha)			-0.003	0.004			-0.011	0.006**
Total cropped area (Ha)	0.016	0.039	0.01	0.001***	0.629	0.040***	0.01	0.002***
Hosted wheat demonstration/ PVS trials {1=yes, 0=No}	0.084	0.063	1.053	0.180***	0.173	0.109***	0.921	0.309***
Visited demonstration fields or attended field days {1=yes, 0=No}	0.056	0.065	-0.585	0.139***	-0.195	0.067***	0.22	0.136*
Price of seed	-0.661	0.264***	0.001	0.001**	-0.089	0.179	0.001	0.000***
Constant	6.893	1.871***	-2.456	1.221**	1.792	1.41	-3.464	1.146***

Description of dependent variables:

- *Selection equation: Adoption dummy = a dummy variable for the adoption of the improved wheat variety which takes a value of 1 if the farmer is an adopter and 0 otherwise*
- *Outcome equation: Area under the new varieties (ha),*

, ** and * respectively represent significance at 0.1, 0.05 and 0.01 levels.*

Farmers hosting demonstration trials on their own farm were also found to be more inclined to adopt improved wheat varieties. This result fits theoretical expectations as demonstration trials give the farmer hands-on training and first-hand information about the pros and cons of the technology (Yigezu et al., 2019b).

6.6.3 Impacts of improved wheat varieties

6.6.3.1 Impacts on yield

Table 6.22 shows the results of the two-stage least squares estimate of the instrumental variables (IV) regression model for yield. Input quantities (nitrogen and phosphors fertilizers, and total amount of seed used) were found to have positive and significant effects on yield. These were consistent with theoretical expectations in the three revisited provinces, both in the 2012/13 and 2016/17 cropping seasons. Likewise, irrigated plots gave higher yields than non-irrigated plots– showing a clear advantage for irrigation in both cropping seasons though the net benefits are less than for rainfed areas due to additional costs incurred in wheat production. Eshete et al 2021 argued that results of a cost–benefit analysis made it clear that farmers can reduce their seed costs through seed recycling, but their yields and net income can be best improved by using unrecycled certified seed of bread wheat. These results are intuitive as both irrigation and certified seeds are generally known to enhance yields.

Model results showed the adoption of improved varieties in the three revisited provinces led, on average, to yield gains of about 735.61 kg/ha (18%) and 1353.86 kg/ha (25.5%), respectively in the 2012/13 and 2016/17 cropping seasons. The results of the alternative ordinary least squares (OLS) regression also showed comparable yield gains from adopting the improved wheat varieties – indicating the strength of our results. These are consistent with many studies that found clear advantage of using improved varieties on crop productivity (Yigezu et al.2019b, Mazid et al., 2015). The rest of our analysis considers the results of the 2SLS as they're consistent with the OLS results and also account for possible endogeneity of treatment in case the tests failed to capture it.

6.6.3.2 Impacts on gross margins

Table 6.23 below provides estimates of the instrumental variables (IV) regression for gross margins. As this section's main objective is to measure the impacts of adoption of improved varieties, we'll only briefly discuss the determinants of yield. Irrigated plots gave higher gross margins than non-irrigated plots, which for fixed prices of inputs and outputs from both irrigated and rainfed areas, could be explained purely by the yield gains that more than offset the additional costs of irrigation.

After controlling for all confounding factors in the gross margins equation, our results show adoption of improved wheat varieties by the typical Uzbek wheat farmers led to about 194,921.3 UZS[18] or 93.7 USD (16.2%) and 367,364 UZS or 129.3 USD (25.1%) higher gross margins per ha in the three revisited provinces in 2012/13 and 2016/17 cropping seasons, respectively. These results are consistent with the findings of Yigezu et al., (2019b) and Mazid et al., (2015).

[18] *The exchange rate in 2012 was 1USD = 2,081 UZS, while the exchange rate in 2017 was 1 USD = 3,480 UZS. These rates are obtained from : https://freecurrencyrates.com/en/exchange-rate-history/USD-UZS/2013/yahoo*

Table 6.22. Two-stage least squares (2SLS) estimates of the IV model for yield (kg/ha)

	Only the three revisited provinces (2012/13 cropping season)				Only the three revisited provinces (2016/17 cropping season)			
	Adoption of improved varieties (No=0, Yes=1)		Yield (kg/ha)		Adoption of improved varieties (No=0, Yes=1)		Yield (kg/ha)	
Independent Variables	**Coef**	**Std.Er**	**Coef**	**Std.Er**	**Coef**	**Std.Er**	**Coef**	**Std.Er**
ImpvVar (No=0, Yes=1)			0.180	0.048***			0.255	0.069***
Age (Years)	-0.004	0.050	-0.001	0.009	0.007	0.057	0.029	0.021
Sex (0=Male, 1=Female)	-0.030	0.061	-0.010	0.011	0.112	0.068*	0.038	0.026
Number of years in education	0.005	0.022	0.027	0.004***	0.047	0.028*	0.020	0.012*
Total amount of labour used (Person days/ha)	0.034	0.054	0.057	0.009***	-0.016	0.019	-0.001	0.007
Got credit	-0.004	0.024			0.079	0.031***		
Irrigated {1=yes, 0=No}	-0.313	0.300	1.189	0.053***	-0.566	0.182***	1.330	0.070***
Wheat area (Ha)	-0.023	0.014*	-0.007	0.003***	-0.065	0.028**	-0.058	0.006***
Total cropped area (Ha)	0.016	0.021			0.082	0.030***		
Off-farm employment {1=yes, 0=No}	0.078	0.042*			0.052	0.033		
Seed price	-0.079	0.090			0.171	0.095*		
Amount of seed used(kg/ha)	1.370	0.365***	0.131	0.089	-0.013	0.153	0.109	0.057**
Quantity of nitrogen fertilizer used (kg/ha)	0.327	0.093***	-0.036	0.022**	0.451	0.091***	0.096	0.037***
Quantity of phosphors fertilizer used (kg/ha)	0.107	0.041***	-0.007	0.009	0.052	0.030*	0.030	0.011***
Hosted wheat demonstration trials 1=yes,0=No}	0.149	0.063**			0.136	0.046***		
Visited demonstration fields or attended field days {1=yes, 0=No}	-0.097	0.047**			0.025	0.032		
Constant	-7.051	1.787***	6.481	0.453***	-2.792	1.128***	6.090	0.346***

Table 23. Two-stage least squares (2SLS) estimates of the IV model for gross margins (UZS /ha)

Variables	Only the three revisited provinces (2012/13 cropping season)				Only the three revisited provinces (2016/17 cropping season)			
	Adoption of improved varieties (No=0, Yes=1		Gross margins		Adoption of improved varieties (No=0, Yes=1)		Gross margins	
Independent Variables	Coef	Std.Er	Coef	Std.Er	Coef	Std.Er	Coef	Std.Er
ImpvVar (No=0, Yes=1)			0.162	0.058***			0.251	0.095***
Age (Years)	-0.004	0.050	-0.022	0.010**	0.007	0.057	-0.001	0.029
Sex (0=Male, 1=Female)	-0.030	0.061	-0.011	0.013	0.112	0.068*	0.024	0.036
Number of years in education	0.005	0.022	0.021	0.005***	0.047	0.028*	0.017	0.016
Total amount of labour used (Person days/ha)	0.034	0.054	0.046	0.010***	-0.016	0.019	0.008	0.009
Got credit	-0.004	0.024			0.079	0.031***		
Irrigated {1=yes, 0=No}	-0.313	0.300	1.111	0.064***	-0.566	0.182***	1.223	0.096***
Wheat area (Ha)	-0.023	0.014*	-0.002	0.003	-0.065	0.028**	-0.035	0.009***
Total cropped area (Ha)	0.016	0.021			0.082	0.030***		
Off-farm employment {1=yes, 0=No}	0.078	0.042*			0.052	0.033		
Seed price	-0.079	0.090			0.171	0.095*		
Amount of seed used(kg/ha)	1.370	0.365***	-0.206	0.108**	-0.013	0.153	0.147	0.078*
Quantity of nitrogen fertilizer used (kg/ha)	0.327	0.093***	-0.042	0.026	0.451	0.091***	0.094	0.051**
Quantity of phosphors fertilizer used (kg/ha)	-0.107	0.041***	-0.014	0.011	0.052	0.030*	-0.033	0.015**
Hosted wheat demonstration trials 1=yes,0=No}	0.149	0.063**			0.136	0.046***		
Visited demonstration fields or attended field days {1=yes, 0=No}	-0.097	0.047**			0.025	0.032		
Constant	-7.051	1.787***	14.515	0.547***	-2.792	1.128***	11.669	0.473***

6.6.3.3 Impacts on consumption

Table 6.24 below provides estimates of the instrumental variables (IV) regression model for consumption. The results show adopters of improved varieties, on average, consume about 14.4 kg/capita/year (25.4%) and 22.3 kg/capita/year (32.7%) more wheat than the counterfactual in the three revisited provinces in 2012/13 and 2016/17 cropping seasons, respectively. This shows the yield and income gains also translated into improvements in food intake by the families of adopter households.

Table 6.24: Two-stage least squares (2SLS) estimates of the IV model for wheat consumption (kg/capita/year)

	Only the three revisited provinces (2012/13 cropping season)				Only the three revisited provinces (2016/17 cropping season)			
					Adoption of improved varieties (No=0, Yes=1)		Wheat Consumption (kg/capita/year)	
Independent Variables	**Coef**	**Std.Er**	**Coef**	**Std.Er**	**Coef**	**Std.Er**	**Coef**	**Std.Er**
ImpvVar (No=0, Yes=1)			0.254	0.109***			0.327	0.127***
Age (Years)	-0.004	0.050	-0.126	0.038***	0.007	0.057	-0.041	0.039
Sex (0=Male, 1=Female)	-0.030	0.061	-0.076	0.047	0.112	0.068*	-0.026	0.048
Number of years in education	0.005	0.022	0.042	0.018**	0.047	0.028*	0.019	0.021
Total amount of labour used (Person days/ha)	0.034	0.054	-0.380	0.045***	-0.016	0.019	0.008	0.013
Got credit	-0.004	0.024			0.079	0.031***		
Irrigated {1=yes, 0=No}	-0.313	0.300	-0.172	0.259	-0.566	0.182***	0.151	0.128
Wheat area (Ha)	-0.023	0.014*	0.137	0.013***	-0.065	0.028**	0.000	0.012
Total cropped area (Ha)	0.016	0.021			0.082	0.030***		
Off-farm employment {1=yes, 0=No}	0.078	0.042*			0.052	0.033		
Seed price	-0.079	0.090			0.171	0.095*		
Amount of seed used(kg/ha)	1.370	0.365***	0.824	0.284***	-0.013	0.153	-0.102	0.105
Quantity of nitrogen fertilizer used (kg/ha)	0.327	0.093***	-0.176	0.108*	0.451	0.091***	-0.046	0.068
Quantity of phosphors fertilizer used (kg/ha)	-0.107	0.041***	0.146	0.034***	0.052	0.030*	-0.027	0.021
Hosted wheat demonstration trials 1=yes,0=No}	0.149	0.063**			0.136	0.046***		
Visited demonstration fields or attended field days {1=yes, 0=No}	-0.097	0.047**			0.025	0.032		
Constant	-7.051	1.787***	1.703	1.115	-2.792	1.128***	4.855	0.635***

During the two surveys, farmers were asked to give their opinions on the impacts of improved wheat varieties (Table 6.25). In theory, improved varieties are bred and disseminated because they're believed to provide higher and more stable yields, including resistance to different biotic and abiotic stresses. However, the question is how well farmers' perception of the importance of the varietal traits matches their perceptions and how well those traits are being available in the improved variety (Alemu and Bishaw, 2016). In reality, as well, empirical evidence from our surveys in Uzbekistan and from similar studies in Morocco and Turkey, clearly show improved varieties have led, among other things, to higher yields and hence higher farm income and consumption.

Table 6.25: Stated impacts of improved wheat varieties

	All 8 provinces (2012/13 cropping season)			Only the three revisited provinces (2012/13 cropping season)			Only the three revisited provinces (2016/17 cropping season)		
Change in:	**Decreased**	**No change**	**Increased**	**Decreased**	**No change**	**Increased**	**Decreased**	**No change**	**Increased**
Availability of wheat for food at home	0.1	4.9	95	0.18	5.4	94.4	1.1	26.7	72.2
Availability of other food items	0	15.8	84.2	0	6.9	93.1	0.2	31.1	68.8
Cash income from selling wheat	1.3	10.1	88.6	2.3	14.3	83.3	0.5	25.3	74.2
Investment in children's education	0	10	90	0	6.9	93.1	0.1	23.8	75.2
Investment in health for the family	24.4	21	54.6	0	19.9	80.1	0.9	31.9	67.3
Investment in livestock husbandry	0	18.5	81.5	0	16.3	83.7	0.5	20.4	79.1
Investment in clothing and footwear for family	0.1	9	90.9	0	12	88	0.5	13.9	85.6
Investment in household utensils	0	18.8	81.2	0	25	75	0.4	42.1	57.6
Investment in residential house (size and quality)	0	17.6	82.4	0	40	60	0.1	36.9	62.1
Investment in communication (phone, TV, etc.)	0	4	96	0	16	84	0.7	11.1	88.2
Investment in transport (bicycle, horse, mule, etc.)	0	19.7	80.3	0	25	75	0.7	18.9	80.5
Investment in fertilizer use for crop production	0	26	74	0	23	77	0.7	17.9	81.4
Investment in social activities	0.1	44	55.9	0	45	55	0.5	41.7	57.9
More time for leisure	3.5	78.5	18	2	80	18	4.5	77	18.5

6.6.3.4 National impacts at observed adoption levels

The total wheat area in 2012/13 in the three revisited provinces covered by the first survey was 428,595 ha, of which 80.41% (344,633 ha) was under improved varieties of wheat that were 10 years old or under. Given the average yield gain of 735.6 kg/ha for adopters at the time, introducing improved wheat varieties had led to the production of an extra 0.25 million tons of wheat in the three provinces. This represents about a 14.5% increase in annual production in the three revisited provinces. Assuming, on the average, adoption levels and yield impacts in other wheat growing areas not covered by the survey were also the same, Uzbekistan was producing 0.85 million tons (14.5%) more wheat annually due to adopting improved varieties in 2012/13 and possibly many years before.

In 2016/17, about 79.2% of total wheat area in the three revisited provinces was under improved varieties of wheat. Given the average yield gain of 1353.8 kg/ha for adopters at the time, introducing improved wheat varieties had led to an extra 0.46 million tons of wheat in the three provinces. This represents about a 20.2% higher annual production in the three provinces. Assuming, on average, adoption levels and yield impacts in other wheat-growing areas not covered by the survey were also the same, nationally, Uzbekistan was producing an extra 1.54 million tons (20.2%) more wheat annually due to adopting improved varieties. This level of increase in total national food production is high and shows introducing improved wheat varieties is making a sizeable contribution to national food security and Uzbekistan's effort for food self-sufficiency in 2016/17 and possibly many years before and after.

Based on the data from the first survey, the gain in gross margins due to an 80.41% level of adoption of improved varieties observed in the three survey provinces in the 2012/13 cropping season was about 67.2 billion UZS (32.3 million USD). This represents an extra gain of 13% in gross margins from wheat production in these provinces at the time. Assuming the adoption levels and yield impacts in other wheat growing areas not covered by the survey were, on average, the same as the average of the three provinces, the three provinces were earning a net wheat income gain of at least 1.7 trillion UZS (0.83 billion USD) per year between 2012/13 and 2016/2017.

Likewise, based on data from the second survey, the gain in gross margins due to the 79.2 % level of adoption of improved varieties in the three survey provinces in the 2016/17 cropping season was about 124.7 billion UZS (43.9 million USD). This represents an extra gain of 20% in total gross margins from wheat production in the three sample provinces at the time. Assuming the adoption levels and yield impacts in other wheat growing areas not covered by the survey were, on average, the same as the average of the three provinces, Uzbekistan was earning a net wheat income gain of at least 2.1 trillion UZS (0.7 billion USD) per year ever since.

Considering the total population of Uzbekistan in 2017 of about 33 million, and the average recommendation by the Uzbekistan Ministry of Health of 147 kg/capita/year of wheat grain (Mirkasimov and Parpiev, 20.17), the extra 1.54 million tons of wheat produced due to adopting improved wheat varieties translates to about 46.6 kg/capita/

year (31.7%) of extra wheat availability in the country. This calculation, however, assumes that differences in access and entitlement to produced wheat or possible qualitative and quantitative changes in consumption are non-existent, both of which are unrealistic.

6.6.3.5 Potential national impacts

While current adoption levels are good, and the gain in total production and hence contribution to national food security and food self-sufficiency are sizeable, it's worth mentioning that improved varieties released since these two surveys could lead to even higher yields. Assuming the yield gains per unit area observed in the three survey provinces in the 2012/13 and 2016/17 remained the same after each survey, if adoption of improved varieties increased to higher levels, the three provinces would benefit even more.

Between 2016 and 2020, average annual total wheat production in Uzbekistan stood at about 6.1 million tons (FAOStat, 2021). Assuming the current adoption level and yield impacts in other wheat growing areas not covered by the survey were, on average, the same as the average of the three provinces (79.2%), Uzbekistan has been producing 1.54 million tons (25%) more wheat and generating 2.1 trillion UZS (0.74 billion USD) in extra wheat income every year since 2016/17 (Table 6.26).

Table 6.26: Potential national impacts of improved wheat varieties with different assumed levels of adoption levels

Assumed adoption level	Estimated national gain in the 2012/13 season at different assumed adoption levels			Assumed adoption level	Estimated national gain in the 2016/17 season at different assumed adoption levels		
	Production (million tons)	Gross margins (billion UZS)	Gross margins (billion USD)		Production (million tons)	Gross margins (billion UZS)	Gross margins (billion USD)
Current level (80.41%)	0.85	1730.23	0.83	Current level (79.2%)	1.54	2104.66	0.74
85%	0.90	1828.99	0.88	85%	1.65	2258.79	0.80
88%	0.93	1893.55	0.91	88%	1.71	2338.51	0.82
90%	0.95	1936.58	0.93	90%	1.75	2391.66	0.84
95%	1.00	2044.17	0.98	95%	1.85	2524.53	0.89
100%	1.06	2151.76	1.03	100%	1.94	2657.40	0.94

This shows that improved varieties have contributed substantially to food security and income for Uzbekistan's wheat farmers. What's more, varieties released more recently might have higher yield potential, hence the country generally, and individual farmers particularly, could expect even higher benefits than those seen during the surveys. The data in Table 6.27 supports this finding and shows how grain yields vary based on variety age and agro-ecologies, and how gross margins decrease as the age of a variety increases.

Table 6.27: Yields and gross margins by year of release and agro-ecology

	Only the three revisited provinces (2012/13 cropping season)				Only the three revisited provinces (2016/17 cropping season)			
	Irrigated		Rainfed		Irrigated		Rainfed	
Released in or after this year	Yield (kg/ ha)	Gross margins (UZS /ha)	Yield (kg/ ha)	Gross margins (UZS /ha)	Yield (kg/ ha)	Gross margins (UZS /ha)	Yield (kg/ ha)	Gross margins (UZS /ha)
1900	3361.0	679576.0	657.7	180956.8				
1980	4272.3	707038.3	709.3	223639.5	4401.5	1105159.8	1047.1	286700.0
1981	4044.5	697499.5	741.6	272458.8			733.3	156902.7
1983					4515.0	1239914.3		
1990					4783.8	1305075.5		
1993	4956.2	877662.6			5155.4	1324389.4		
1999								
2000	4718.2	837949.3	1232.1	279221.0	5742.2	1577907.5	1400.0	315280.2
2001	5004.7	878712.0	1200.4	276474.5	5806.9	1677547.9		
2002							1027.5	286293.4
2003	5218.8	901717.8			5400.0	1405233.2		
2004	5031.4	848250.8			5300.0	1521600.8		
2005	4769.8	781613.5	1224.2	296817.0	5212.5	1498992.0		
2006	5300.5	903591.9	1338.3	280999.5	5447.2	1576422.0	1123.0	434996.0
2007					5566.7	1573296.4		
2008	5479.7	950756.3			5978.4	1594262.6	1223.1	440895.3
2009	5356.4	919748.1	1319.3	275526.7				
2010	5697.9	988186.2	1274.1	260646.0	5426.7	1549515.2	1617.7	491471.5
2011	5725.3	985105.9			5656.7	1574512.7	1137.3	380237.4
2012	5722.1	988983.7	1311.2	279178.8	5527.1	1409465.0	1189.1	441486.6
2013	5687.5	980739.8			5385.7	1571612.5	1411.5	438976.1
2014					5840.5	1604080.8	1319.2	437010.0
2015					6793.7	1740383.8		
2016					5791.4	1602202.9	1430.8	448793.4
Total	**5171.8**	**884105.4**	**993.2**	**247606.6**	**5559.4**	**1533013.8**	**1310.2**	**406226.0**

6.6.4 Seed demand analysis

6.6.4. 1 Quantity of seed used by geographic and agro-ecological zones

Looking at all eight provinces covered in the 2012/13 survey, the typical sample farmer was using about 214 kg of wheat seed per hectare (222 kg/ha for irrigated and 124 kg/ha for rainfed). Whereas among the three revisited provinces, the average farmer was using about 208.5 kg of wheat seed per hectare (222.8 kg/ha for irrigated and 123.8 kg/ha for rainfed) in 2012/13. The corresponding figures during the second survey in 2016/17 in the three revisited provinces showed a national average of 214.7 kg/ha (222.2 kg/ha for irrigated and 114.5 kg/ha for rainfed).

Applying the area weights to the individual provinces, the total amount of seed used in the eight provinces was estimated at 0.19 million tons per year. The total seed used in the three provinces in 2012/13 and 2016/2017 cropping seasons was 87.2 and 89.09 thousand tons per year, respectively. This showed seed rates remained almost the same. Therefore, assuming the same seeding rate for the provinces that were not covered by our sample and based on the five-year (2012-2016) average total national wheat area of 1.44 million ha, the amount of national wheat seed use in 2016/17 was estimated at 308,160 tons. This is comparable with the total annual seed use of 0.30-0.32 million tons estimated by Khalikulov et al. (2016). In 2015/16, the total certified seed production reported by the MoA was 293,906 tons. This shows that in 2016/17, about 95.4% of total wheat area (i.e., 293,906/308,160) was planted with certified seed. Our estimated total seed use is only 2.4% higher, which represents the quantity of seed used by farmers who saved seed from their own grain production the previous year, or who bought seed from the market.

Among the eight provinces included in the first survey, Qashqadarya and Jizzakh used the highest amount of seed (43,900 and 40,400 tons), while Navoi used the least (9,800 tons). Analyzing the trend in the quantity of seed use between 2012/13 and 2016/17 showed that while there were increases in seed use in Andijan and Tashkent, the total quantity of seed used in Qashqadarya decreased (Table 6.28).

Table 6.28: Estimated total seed use by province (8 sample provinces)

	All 8 provinces (2012/13 cropping season)	Only the three revisited provinces (2012/13 cropping season)	Only the three revisited provinces (2016/17 cropping season)
PROVINCE	**Total (tons)**		**Total (tons)**
Karakalpakstan	11,838		
Andijan	16,887	16.887	17.518
Bukhara	14,745		
Jizzakh	40,387		
Qashqadarya	43,875	43.875	42.444
Navoi	9,828		
Samarkand	33,037		
Tashkent	26,659	26.659	29.128
Total	**196,320**	**87.178**	**89.090**

6.6.4.2 Quantity of seed used by variety and by source

Our survey results showed, in descending order, Tanya, Krasnodarskaya99, Bobur, Esaul, and Kroshka were the top five varieties with the highest seed use in Uzbekistan in the eight provinces included in the first survey. Considering only the three revisited provinces, Tanya, Bobur, Krasnodarskaya99, Tezpishar, Esaul were the top five varieties with the highest seed use. Whereas in 2016/17, the top five varieties with the highest seed use in the three revisited provinces were Krasnodarskaya99, Grom, Tanya, Andijan4? and G'ozg'on. Secondary data sources also show the total amount of certified seed produced and distributed in the country follows similar patterns (Table 6.29). These results are consistent with the adoption degree by variety in section 6.6.2.5 where, though in slightly different order, these same varieties occupy the largest area relative to other varieties.

Table 6.29: Total seed use and certified seed production by variety (eight sample provinces)

All eight Provinces (2012/13 cropping season)			Only the three revisited provinces (2012/13 cropping season)		Only the three revisited provinces (2016/17 cropping season)		
Total national seed use (million kg)			Total national seed use (million kg)		Total national seed use (million kg)		
Rank	**Variety**	**Amount used (million kg)**	**Variety**	**Amount used (million kg)**	**Rank**	**Variety**	**Amount used (million kg)**
1	Tanya	53.18	Tanya	23.72	1	Krasnodarskaya99	17.29
2	Krasnodarskaya99	39.24	Bobur	13.52	2	Grom	16.19
3	Bobur	22.42	Krasnodarskaya99	13.14	3	Tanya	12.86
4	Esaul	8.40	Tezpishar	3.39	4	Andija 4	6.05
5	Kroshka	6.50	Esaul	3.15	5	G'ozg'on	4.64
6	Nota	5.94	Moskvich	3.00	6	Vassa	4.32
7	Andijan2	4.86	Turaqurgon_1l	2.55	7	Bobur	4.13
8	Moskvich	4.21	Oq Bugdoy	2.14	8	Gratsiya	2.91
9	Chillaki	4.06	Chillaki	2.12	9	Kroshka	2.84
10	Andija 4	3.71	Andijan1	1.85	10	Yaksart	2.47
11	Turaqurgon_1l	3.67	Nota	1.85	11	Chillaki	1.81
12	Tezpishar	3.66	Kokbulak	1.34	12	ASR	1.43
13	Oq Bugdoy	3.50	Mars1	1.25	13	Andijan1	1.41
14	Starshina	3.18	Elita	1.14	14	Hazrati bashir	1.40
15	Mars1	2.26	Jayhun_Zamin1	1.10	15	Kupava	1.19
16	Andijan1	2.15	Intensivnaya	1.09	16	Lebed	1.14
17	Vostorg	2.15	Andija 4	1.03	17	Matonat	1.08
18	Yaksart	2.01	Vostorg	1.03	18	Sanzar4	0.65
19	Polovchanka	1.85	Rapsodia	1.03	19	Tezpishar	0.65
20	Fortuna	1.62	Kroshka	0.97	20	Muftallo	0.56
21	Kokbulak	1.44	Krasnovodopadskaya210	0.95	21	Zvezda	0.53
22	Nikoniya	1.39	Knyajna	0.93	22	Vostorg	0.49
23	Jayhun_Zamin1	1.37	Selyanka Odesskaya	0.71	23	Zemnitsa	0.35
24	Gratsiya	1.34	Gratsiya	0.53	24	Durdona	0.35
25	Umanka	1.29	Polovchanka	0.50	25	Semurg	0.33
26	ASR	1.28	Fortuna	0.47	26	Bahmal97	0.26
27	Elita	1.23	Kupava	0.45	27	Andijan2	0.23

All eight Provinces (2012/13 cropping season)			Only the three revisited provinces (2012/13 cropping season)		Only the three revisited provinces (2016/17 cropping season)		
Total national seed use (million kg)			Total national seed use (million kg)		Total national seed use (million kg)		
Rank	Variety	Amount used (million kg)	Variety	Amount used (million kg)	Rank	Variety	Amount used (million kg)
28	Intensivnaya	1.17	Andijan2	0.38	28	Jayhun_Zamin1	0.23
29	Rapsodia	1.11	Surkhon	0.34	29	Yanbosh	0.21
30	Krasnovodopadskaya210	1.02	Dustlik	0.28	30	Kokbulak	0.20
31	Knyajna	1.00	Kuma	0.27	31	Yuka	0.19
32	Grom	0.98	Umanka	0.25	32	Zumrad	0.18
33	Selyanka Odesskaya	0.88	Grom	0.20	33	Bunyodkor	0.16
34	Kupava	0.50	Nikoniya	0.20	34	Omad	0.14
35	Kuma	0.46	Turkiston	0.14	35	Moskvich	0.11
36	Surkhon	0.36	Sanzar 6	0.09	36	Intensivnaya	0.06
37	Dustlik	0.31	Yaksart	0.07	37	Grekum439	0.03
38	Yanbosh	0.29			38	Sanzar 6	0.02
39	Turkiston	0.15			39	Krasnovodopadskaya210	0.02
40	Sanzar 6	0.10					
41	Zumrad	0.05					
	Total	**196.32**		**87.178**	**Total**		**89.09**

Note: Varieties in red color font are from the CGIAR.

Analyzing the actual quantity and source of seeds used for the 2012/13 cropping season showed that out of the total wheat seed used, nationally, 83.9% of farmers (87% fermers and 75.7% dehkans) reported they obtained their seed from public seed companies. The remaining 16.1% (13% fermers and 24.3% dehkans) obtained theirs from other sources including local seed traders in neighboring villages, and own-saved seed. In the three revisited provinces alone, during the same period, 90.8% of farmers said they obtained theirs from public seed companies (Table 6.30) while the remaining came from other sources.

In contrast, during 2016/17, 93% of the farmers said they got their seed from public seed companies. The remaining 7% from own saved seed from the 2015/16 grain production. This shows farmers' reports of 7% uncertified seed is higher by 2.4% than the 4.6% uncertified seed use estimated above – i.e., the difference between estimated seed use based on per unit area seeding rate from our survey in 2016/2017, and the official statistics from MoA. The high discrepancies between the common knowledge

of nearly 100% certified seed coverage (i.e., annual certified seed replacement) in Uzbekistan and our results from both surveys (but especially for 2012/13) are puzzling. While further investigation is warranted to understand the main reason(s) behind these discrepancies, one or a combination of two or more of the following may provide possible explanations:

1) The amount of certified seed received may not be sufficient for some farmers who use higher seeding rate for which they might be using their own saved seed to fill the shortfall.
2) Some important varieties are missing in the 2016 seed production list. This means, farmers were using their own saved seed for such varieties.
3) Some farmers may have obtained certified seed, but not directly from public sources.
4) Farms who are under quota system certainly purchase certified seeds because they get input credit at low rates. Therefore, such low rate of certified seed use could possibility be because:
    a. Some of the respondents may not fully understand the term "certified seed"
    b. Some farmers may indeed purchase certified seeds (as they need the low interest credit) but for one reason or another plant seed purchased from the market;
5) In those particular years, farm-saved seed could have been used to cover certified seed deficit resulting from high rejection rate or other factors such as exclusion of varieties from production due to susceptibility to rust or other biotic stresses;
6) Assuming 100% coverage of certified seed, it could be one generation away from certified seed (R3) where the seed is cleaned and treated and tested except that the previous history of the land may have been known (central plan) or may not have been known.

Table 6.30: Total quantity of seed used by Source

	All 8 provinces (2012/13 cropping season)		Only the three revisited provinces (2012/13 cropping season)		Only the three revisited Provinces (2016/17 Cropping season	
Total Seed Used/Source	**Total amount of seed (in tons)**	**% Share out of total seed used**	**Total amount of seed (in million kg)**	**% Share out of total seed used**	**Total amount of seed (in million kg)**	**% Share out of total seed used**
Public seed companies	164.76	83.93	79.14	90.78	82.85	93
Private seed companies	0.37	0.19	0.34	0.39	-	
Agro-dealers/Agro-vets in the village	0.10	0.05	0.10	0.11	-	
Extension demo plots	2.45	1.25	-	-	-	
On-farm trials (research)	0.07	0.04	0.07	0.08	-	
Local seed producers	0.20	0.10	0.18	0.21	-	
Local grain market	8.13	4.14	5.42	6.21	-	
Trader outside the village	2.05	1.04	0.46	0.52	-	
Own saved seed	18.18	9.26	1.48	1.70	6.24	7
Total	196,320	100%	87,178	100%	89,090	100%
Purchased from other farmers	30,630	15.6	15,090	17.26	-	
Total	**196,320**	**100%**	**87,420**	**100%**	**89,090**	**100%**

In the three revisited provinces, only 50.5% and 52.8% of the 17% farmers who saved their own seed for the 2012/2013 and 2016/2017 cropping seasons said they treated their seed. The remaining 49.5% and 47.2%, respectively, didn't treat their seed. For storage, however, a relatively higher proportion (60% and 65%) said they store their own saved seed separately (Table 6.31). About 65% and 70% of these farmers store their seed in jute bags kept inside the house and another 35% and 30% in polypropylene bags kept inside the house (Table 6.32). Studies from Ethiopia (Bishaw et al., 2010) and Syria (Bishaw et al., 2011) on wheat and barley seed source and management showed most wheat and barley producers store their own saved seed. While seed treatment and jute or polypropylene bags are most common for wheat in Syria, there's no seed treatment in Ethiopia, but there is a traditional common storage structure called a gotera.

Table 6.31: Own-saved seed treatment and storage

	All 8 provinces (2012/13 cropping season)		Only the three revisited provinces (2012/13 cropping season)		Only the three revisited Provinces (2016/17 Cropping season	
	If farm saved, did you treat your seed?	**Did you store seed separate from other grains?**	**If farm saved, did you treat your seed?**	**Did you store seed separate from other grains?**	**If farm saved, did you treat your seed?**	**Did you store seed separate from other grains?**
Yes	46.3	64.4	50.5	60	52.8	65
No	53.7	35.6	49.5	40	47.2	35
Total	**100**	**100**	**100**	**100**	**100**	**100**

Table 6.32: Mode of storage for own saved seed

	All 8 provinces (2012/13 cropping season)	Only the three revisited provinces (2012/13 cropping season)	Only the three revisited Provinces (2016/17 Cropping season
Where do you store the seed?	**% of farmers**	**% of farmers**	**% of farmers**
In jute bags kept in house	63	65	70
In polypropylene bags kept in house	35	35	30
In jute bags kept in storage area outside house	2	0	0
Total	**100**	**100**	**100**

6.6.4.3 Amount of seed used by type and analysis of farmers' seed choices

In 2012/13, out of the total seed used by farmers in all eight provinces and the three revisited provinces, 83.93% and 90.78%, was certified. The remaining 16.07% and 9.22% was uncertified – leading to an average seed replacement rate of 1.19 and 1.11 years, respectively. This indicates most farmers were replacing their seed every year with some replacing every two, three, or more years. The percentage of farmers in the three revisited provinces who used certified seeds increased to 93% in the 2016/17 cropping season, thereby making the seed replacement rate even lower (1.07 years), i.e., seed replacement is faster in 2016/17.

Asked about the names of their most preferred variety, the top five wheat varieties mentioned by farmers which they knew or had heard about in the 2012/13 cropping season were Tanya (28.7%), Bobur (22.1%), Nikoniya (16.1%), Knyajna (11.4%), and Krasnodarskaya99 (10.3%). Among the three revisited provinces included in the first survey, the top five varieties mentioned by farmers were Tanya (15.8%), Bobur (10.7%), Krasnodarskaya99 (8.3%), ASR (8%), and Gratsiya (5.7%). In the 2016/17 cropping season, it was Grom (28.7 %,), Tanya (22.1%), Krasnodarskaya99 (16.1%), Yaksart 10.3% and G'ozg'on (7.8%). While the magnitudes and hence the order of importance might differ slightly, these results are comparable to the top- five varieties grown in each of the two survey years showing farmers

were growing their preferred varieties.

Farmers were also asked if they cultivate their favorite varieties. The answers between the 2012/13 and 2016/2017 cropping seasons are almost identical, as 81.2% of farmers responded "Yes" to the cultivation of their favorite wheat varieties. For those responding "No", the main reason (14.33%) was the absence or non-availability of enough quantities of seed in the market, followed by high prices (5.52%). These results confirm most farmers in Uzbekistan are growing their preferred varieties. However, while average wheat yields have improved substantially over the years (e.g., from 5.0 and 1.0 ton/ha in irrigated and rainfed environments in 2012/13 to 5.3 and 1.2 ton/ha in 2016/17, respectively), the yields in 2016/17 are still considered low. This casts doubt as to whether these varieties were the best available and if private sector participation would lead to better outcomes for adoption and impact.

Moreover, farmers compare what they're using with what's on the menu and hence their report could be correct. However, if they were given varieties with other preferred traits, they might realize the varieties they're getting may not necessarily be the best. These results may be misleading and hence need further investigation through focused studies.

Farmers were also asked what they think would be the best way to solve the current seed related problems. During the 2012/13 survey, they proposed various solutions:

1) Create better access to credit facilities for seed purchase and seed production under irrigation to increase seed availability (31%).
2) Seed companies should know better what farmers want and produce enough quantities of those varieties demanded (25.6%).
3) Being able to buy varieties from local markets (16.5%) – we interpret this as farmers saying the informal sector needs strengthening to fill the gap.
4) Government should intervene and solve these problems and ensure the availability and access to seed (12%).

In response to the question about the main problems or issues related to using certified seeds among the 7% of farmers who didn't use certified seeds, high price was among the main issues for 46% of these farmers, while unavailability of certified seeds in general, and preferred varieties in particular, were important issues for 5% and 31% of farmers respectively. About 5% and 12% of the farmers felt long distances to certified seed distribution centers and lack of access to credit facilities were important factors in their decision to use certified seeds or not. Just 4% of farmers said they occasionally exchange seeds with other farmers, while 63% said once they occasionally save seed from their own wheat grain production from the previous cropping season.

Regarding the quality of certified seeds, about 85% and 81.2% of farmers said they're happy with the varietal purity and physical purity, respectively, of certified seeds sold in the market. The seed health and germination ability of the certified seeds were also considered good by about 91% of respondents.

6.7 Conclusions

Using two surveys carried out in Uzbekistan covering eight provinces in 2013 and only three provinces (drawn out of the eight covered in 2013) in 2018, this study aimed at providing credible estimates of national and provincial adoption levels and impacts of improved wheat varieties – with special attention paid to their release dates.

Survey results showed that the level of adoption of 20 years or older wheat varieties was lower in 2016/17. In contrast, more (56.8%) Uzbek farmers were cultivating under five years old varieties in 2012/13 compared to the 41.8% in 2016/17. These results provide mixed pictures where Uzbekistan is making good progress in taking more than 20 years old varieties out of production but unfortunately, the turnover for most recent (less than five years old) varieties has slowed down. This could possibly be explained by the reduction in the number of varieties released five years prior to the specific survey years from 20 in 2012/13 to only 13 in 2016/17. Varietal replacement may also be affected by other factors including the effectiveness of extension and input (including seed) service delivery systems, and the concordance between breeding objectives and farmers' trait preferences. However, this study was not able to provide full explanation for this undesirable result. Therefore, future research will need to find an explanation for why the speed of diffusion for less than five years old varieties has slowed down.

The collaboration of national agricultural research systems with CGIAR was instrumental not only in the development and introduction of new improved wheat varieties and hence in enhancing varietal diversity but also in enhancing varietal adoption. This is evident from the fact that four varieties were introduced from the joint CIMMYT/ICARDA/Turkey International Winter Wheat Improvement Program (IWWIP) based in Turkey, out of which, three (G'ozg'on, Yaksart, and Bunyodkor) were cultivated by 8.6% of the farmers in the three revisited provinces covering 8.13% of total wheat area in the three revisited provinces.. This clearly shows the importance of the Uzbekistan-CGIAR collaboration.

Among the most important factors determining farmers' decisions to adopt recent improved varieties were their decision to use certified seed and their access to credit. Other factors including hosting own-farm demonstration trials, years in education, and total farm area, also increased farmers' propensity to adopt improved wheat varieties.

The adoption of improved wheat varieties led to improvements in livelihood indicators including 735.61kg/ha (18%) and 1353.86 kg/ha (25.5%) higher yields in the three revisited provinces in 2012/13 and 2016/17 cropping seasons, respectively. This also led to proportionally comparable increases in farm gross margins. The increased yields and incomes also resulted in higher consumption of wheat for each household adopting improved wheat varieties. Nationally, introducing improved wheat varieties in Uzbekistan has led to a total increase in production of 1.54 million tons of wheat every year since 2016/17. This corresponds to about 49.7 kg/capita/year higher wheat availability from domestic production and a total gain in national income of about 2.1 trillion UZS or 0.7 billion USD per year. This clearly shows the benefits of developing

and disseminating improved wheat varieties for food security and reduced poverty.

Among the three provinces included in the first survey, the average seeding rate for wheat in the 2012/13 season was 214 kg/ha. The corresponding figure in the second survey in 2016/17 was 214.7 kg/ha. Considering a five-year average total national wheat area of 1.44 million ha, this translates to a national seed use rate of 308,160 tons per year. Official certified seed distribution data shows 293,906 tons of certified wheat seed was distributed in 2015. This shows the certified seed use rate in the country in 2016/17 was about 95.4%, indicating an average seed replacement rate of 1.04 (i.e., every year).

Analyzing the trend in the quantity of seed use between 2012/13 and 2016/17 showed that Tanya, Krasnodarskaya99, Bobur, Esaul, and Kroshka, in descending order, were the top five varieties with the highest seed use in the eight provinces included in the first survey. Tanya, Bobur, Krasnodarskaya99, Tezpishar, Esaul were the top five varieties with the highest seed use in the revisited three provinces included in the 2012/13 survey. In contrast, the top five varieties with the highest seed use in the country in 2016/17 were Krasnodarskaya99, Grom, Tanya, Andija4 and G'ozg'on. These results are consistent with official statistics on the total amount of certified seed produced and distributed.

Based on these findings, we recommend introducing new wheat varieties together with more frequent extension visits to farmers, along with more on-farm demonstrations. These build awareness and develop farmers' confidence. They also reduce fears associated with adopting new varieties. We also recommend strengthening credit schemes to increase access to finance for all types of farmers and facilitate adoption of improved agricultural technologies. Focusing on the most recent varieties in seed production can also go a long way to enhancing adoption of improved wheat varieties.

Gross margins are also found to be positively associated with the reduction in varietal age. Therefore, to enhance adoption of most recent improved wheat varieties by farmers, policy makers and developers of new technologies must understand farmers' needs and trait preferences. Superiority in yield, marketability, and consumption qualities relative to the best varieties currently under cultivation should constitute the minimum breeding objectives if new improved varieties are to command higher and wider adoption.

CHAPTER VI: Analysis of Adoption, Impacts, and Seed Demand of Improved Wheat Varieties

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CHAPTER VI: Analysis of Adoption, Impacts, and Seed Demand of Improved Wheat Varieties

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Chapter VII

The Wheat Sector in Uzbekistan: Seed Systems, Varietal Adoption, and Impacts – a synthesis

Zewdie Bishaw, Yigezu Atnafe Yigezu, Aziz Nurbekov, and Abdoul Aziz Niane

7.1 Motivation for the study

The genesis of the series of studies on seed systems, varietal adoption, and impacts in Morocco, Turkey, and Uzbekistan emerged from a broader perspective of the dynamics in the Central and West Asia, and North Africa (CWANA) region's wheat sector. First, being the most important strategic food security crop, wheat is cultivated, at varying levels, in all countries across the region. It is also widely cultivated in countries beyond the CWANA region. Second, wheat research has received huge investment at national and international levels and several technologies have been developed and scaled, with varying levels of diffusion achieved across countries. Third, despite a long history of research and wheat seed supply, the public sector continues to dominate the seed delivery landscape, except for a few countries. Fourth, looking at the evolution of the wheat seed sector in developing countries, it is important to draw lessons from the development pathways followed by different countries. In particular, evaluation of the policies and regulatory frameworks put in place, the diversity of public and private seed sector operators allowed to take part, and capacity of national institutions and their relative effectiveness in enhancing the seed sector development will be useful.

This study is the third in a series carried out in three countries. Each based on its contrasting positions of the presence and level of implementation of seed policies and laws, and the diversity of parties in the seed sector – particularly, the degree of private sector participation. Uzbekistan was primarily selected to represent several other countries in the CWANA region with relatively low private sector participation in the seed sector.

This book's main objectives are to:

1) Describe the historical developments and current status of the wheat sector in Uzbekistan (agricultural and seed policies and institutions, including R&D that affects the wheat sector
2) Analyze the diversity of wheat in farmers' fields by taking inventory of all wheat varieties being cultivated in the country
3) Provide credible estimates of adoption of different varieties under cultivation by type of wheat (bread vs. durum), agro-ecology (winter, spring, or facultative), and water source (irrigated or rainfed)
4) Identify factors enhancing or hindering adoption of recent varieties
5) Provide estimates of the impacts of introducing improved wheat varieties
6) Shed some light on persistent questions about the governance and performance of the wheat seed sector
7) Synthesize lessons learned and their implication for designing and formulating effective interventions.

The preceding chapters provided detailed analyses of different topics, and identified major challenges and opportunities within the limits of their individual thematic focus. However, drawingconclusions and making policy and institutional recommendations that aid the development of the wheat sector requires a comprehensive review of the

whole system and critically analyzing the tradeoffs, synergies, links, and intricacies involved in the whole sector. Therefore, this chapter provides a synthesis of the findings of the preceding chapters and is organized as follows:

- Section 7.2.1 synthesizes the trends, achievements, opportunities, and challenges of the wheat sector in Uzbekistan.
- Section 7.2.2 synthesizes the demand-side micro-level analysis, focusing on varietal adoption, impact, and seed demand patterns.
- Section 7.2.3 briefly synthesizes the wheat sector's overall development, focusing on the supply-side policy and institutional factors affecting farmers' access to seeds of recent varieties with their preferred traits.
- Section 7.2.4 comprehensively synthesizes combining both the supply and demand-side factors.
- Section 7.3 provides a conclusion and makes recommendations for the way forward.

7.2 Analysis of wheat sector

Uzbekistan was part of the Former Soviet Union (FSU) until it became independent in 1991. Before independence, it was a major producer of cotton, vegetables, and fruits. About 70% of irrigated land was devoted to cotton production, whereas fodder crops were grown in rotation with cotton and supported limited livestock production. Wheat, though one of the key food security crops, was primarily imported from other regions of the FSU, particularly Kazakhstan where local production met only 20% of domestic demand.

After independence, Uzbekistan's access to strategic food imports became less secure because of the abolition of the centrally coordinated commodity supply and subsidy systems between Russia and its Soviet Socialist Republics. Subsequent economic structural adjustments by the former Soviet Republics made the contracting system less reliable and reduced regional trade. Being a landlocked country with limited access to international markets, ensuring its food security through domestic production became very important for Uzbekistan. The Government embarked on a new "independence in cereals" policy in 1993 and "self-sufficiency in wheat" in 1994. Since then, wheat has captured center stage of Government policy where several efforts have been made to increase wheat grain production through state orders, subsidies, credit provision, and mostly public investment.

The agricultural development policy for achieving food security and economic development enabled rapid progress in the wheat sector. Since independence, wheat has become the second most important crop after cotton. Wheat is included in the mandatory rotation system with cotton, where the state controls production and marketing. Wheat production is all about food security, which makes it politically sensitive. In particular, replacing the current regulated system with fully market-oriented arrangements will not be easy, as it requires making major changes in the overall agricultural policy and

institutional framework. As such, it may not happen anytime soon.

As part of the initiative to ensure national food security, the area under irrigated winter wheat in Uzbekistan has increased more than five-fold, from less than half a million in 1991, to about 1.15 million ha in 2018. It accounts for nearly 35% of total arable land. Average wheat yield increased from 1.71 tons per ha in 1991 to 5.12 tons per ha in 2018, about three-fold. Average yield exceeded five and seven tons/ha-1 on 62 and 10% of wheat growing areas, respectively, in particular, in the fertile Fergana Valley. Wheat production has increased almost 15-fold since 1991, reaching 6.8 million tons per year in 2018 during which domestic wheat production satisfied more than 70% of domestic consumption for food and feed in the country. The increase in wheat production is mainly due to area expansion with more yield gains from introducing new productive improved varieties and intensive crop-management practices.

Uzbekistan went through several waves of farm restructuring and land reallocations, creating a dual system where large and small subsistence type farms co-exist (World Bank et al. 2019). The smallholder farmers (commonly known as *dehkan*[19]) cultivate an average area of 0.5 ha and produce livestock and horticulture products, while the large individual farms, averaging 40-60 ha produce cotton and wheat exclusively, under a centrally planned system in which production orders are given by the state. The 2019 farm restructuring exercise succeeded in doubling the size of cotton and wheat farms to an average of 100 ha.

By administering all lands, the Government has a major role in the agriculture sector. Farmers are provided with land under lease contracts for 50 years, but they're directed which crops to grow to achieve specific national production targets. The target production levels for major crops like cotton and wheat are established based on agro-ecological zones, soil types, and irrigation. For these crops, farmers receive credits for seeds, fertilizers, and other inputs which they repay when their harvest is sold to the Government at a fixed price. Farmers producing more than their quota are free to sell their surplus on the open market, which normally pays much higher prices than the fixed price offered by the Government.

The Government aims to achieve food security through sustainable increases in production of wheat. This is mainly by increasing productivity through crop intensification along with improved agricultural practices involving better varieties and integrated crop management practices. Currently, extra measures are taken to increase wheat production. These include introducing the cluster system in the sector to optimize use of farmland by increasing the size of farms producing wheat, reallocating more land to clusters that are more efficient, and improving crop-rotation options. The wheat clusters buy wheat grain directly from farmers' surpluses at market prices, process the wheat grain, and sell it in the domestic and international markets. It's important to analyze the effect of this approach on productivity, efficiency, and economic returns.

[19] *Small farms or household plots not less than 0.3 ha*

During the FSU era, agricultural production, processing, and marketing was under a centrally planned command economy. Despite several Government reforms since independence, certain features of the command economy persist. The Government procurement system still operates for certain major crops such as wheat and cotton where farmers produce and sell their produce to the Government through a quota system. However, several questions remain on the performance of these changes:

1) Have they contributed to broader economic growth and development? If yes, did the overall efficiency of the system improve?
2) What alternative ways are there to enhance the system's efficiency?
   a. Would a more liberalized and market-oriented system be better?
   b. Or would a hybrid system that combines important elements of a command economy and a market-oriented system be more effective?
3) What policy and institutional changes are needed for the best model to function well?

With respect to adopting improved agricultural technologies, Uzbekistan has shown clear progress with higher adoption of the most recent varieties (for example in 2016/17 compared to 2011/12). However, in relatively lower yield levels for irrigated environments, what is not clear is whether farmers have access to seeds of the best varieties available in the country. Or whether the breeding programs in the country are developing varieties with sufficiently higher-yield potential. This will require comparing them with experimental fields of nationally developed varieties with those of neighboring countries.

Uzbekistan made several farm restructures focused on wheat and cotton, the two strategic crops of high importance. According to the World Bank et al. (2019), the future reform agenda should focus on:

(i) Removing production distortions
(ii) Increasing the impact of public expenditure on the performance of the agriculture sector
(iii) Helping smallholders reduce transaction costs. While it's important to reduce transaction costs, the rationale for why it has to focus only on smallholders isn't clear. Moreover, as mentioned above, the country is currently minimizing the share of smallholdings, so it's important to evaluate the applicability of this recommendation to large farms as well.

7.3 National seed policy and regulatory framework

In Uzbekistan, all national policies and regulatory frameworks related to the agricultural sector are available at the National Database of Regulation of the Republic of Uzbekistan (https://lex.uz/). Corresponding to national and agricultural development policy and strategy outlined in Section 1.5, the Government of Uzbekistan adopted a seed policy in 1996 (Resolution of Cabinet of Ministers #328 (September 19, 1996). All operations in the seed sector carried out by public agencies and the private sector are subject to this policy.

The seed policy has induced rapid changes in the seed sector, particularly in developing several new improved varieties of wheat and cotton and in disseminating the benefits of superior germplasm to farmers in all agricultural zones. Following several reforms, in 2014, the Food and Agriculture Organization of the United Nations (FAO) and the Ministry of Agriculture and Water Resources (MoAWR) – now called Ministry of Agriculture (MoA) – in consultation with stakeholders, have prepared and submitted a seed sector development strategy to the Government for consideration. The strategy contains key policy and legislative issues that would help create a framework for the transition of the seed sector to a market economy, which is still not clearly visible. What is not clear is whether the transition to a market economy will be beneficial, as Uzbekistan seems to be doing much better in its seed-sector performance than other countries in the region that are more market oriented.

The first basic national Seed Law, enacted in 1996, was followed by a succession of amendments in 1997 and 1999. The latest amendment, Seed Law #521 (February 16, 2019), aimed to conserve and effective use genetic resources; plant breeding for development of crop varieties; production and provision of high-quality seed; realization of seed quality assurance, and certification among many others. However, out of the long wish list of reforms, few changes took place on the ground where the public sector continues to dominate the seed sector in general, and the wheat seed sector in particular.

The many reforms in the regulatory framework shows a lack of in-depth analysis of the constraints or proper consultations among stakeholders. Quick policy and regulatory reforms addressing immediate concerns are helpful, but a stable and consistent policy and regulatory direction is necessary for sector development and stakeholder participation in formulating public policy. Such involvement allows room for broader views that counter the uni-directional dictation by Government.

Uzbekistan has a potential role to play in a regional and global seed industry. To develop the national seed sector and align it with the global seed industry, the Government should:

(i) Seek membership of the OECD, ISTA and ISF for the necessary technical support
(ii) Strengthen the national seed association to represent the interests of seed companies at national, regional and global levels
(iii) Support harmonization of policies and regulatory frameworks, with neighbors to enhance regional seed trade.

Previously, the MoWAR (now MoA) was responsible for implementing Government policies, laws, rules and regulations in the agricultural and seed sector. The governance of the seed sector is now more complex and dispersed. The MoA is responsible for agricultural research and development including variety development, testing and release and, through its Seed Production Center and Grain Production Department, is also responsible for seed production. The processing, storage, and marketing of seed – through the Grain Production Joint Stock Company, and seed quality assurance

and certification through State Inspectorate of Agro-industrial Complex – remains the responsibility of the Cabinet of Ministers of Uzbekistan. The checks and balances in seed sector governance is necessary to streamline and align certain functions to increase the efficacy and efficiency of its operations, particularly in variety development, variety release and seed production and certification.

7. 4 Variety development, release and protection

Although, Uzbekistan has long history of agricultural research and plant breeding, even before independence, the current wheat improvement program started in the early 1990s following independence from FSU. Several institutions are responsible for wheat improvement, each targeting specific agro-ecological zones of the country (Nurbekov et al., 2006). Among these, the major ones include the:

- Research Institute of Cereal and Legume Crops, which targets irrigated agro-ecologies in research carried out in the Andijan Research Station, while targeting rainfed agro-ecology through work carried out in the Gallayaral Research Station.
- Research Institute of Plant Industry (in Tashkent), which targets both irrigated and rainfed environments.
- Samarkand Institute of Agriculture (Samarkand), now a branch of the Tashkent State Agrarian University (Tashkent), which targets the irrigated agro-ecology.

Previously, many foreign wheat varieties, mainly from Russia and Ukraine, were introduced to Uzbekistan and widely grown. For example, in 1997, all irrigated wheat area was occupied by varieties introduced from Russia (Nurbekov et al., 2006). However, these varieties are not tolerant to high temperature and diseases such as wheat rusts. Establishing national breeding programs and collaborating with CGIAR centers has enabled the development of several new improved wheat varieties that are locally adapted and spread the benefits of superior germplasm to farmers in all agro-ecological zones of the country.

Unpublished data from SVTC showed 184 wheat varieties (167 bread and 17 durum) were released between 1940 and 2020 in Uzbekistan (Table 3.1, Figure 2.2 and Annex 2). Very limited number of varieties were released before independence, but the trend changed afterwards with higher number of releases which continued to increasewith time. Accordingly, only seven varieties were registered between 1940 and 1980 and 23 varieties were reported between 1990 and 1999. After 1999, varietal release picked up with 52 varieties released between 2000 and 2010 and 102 varieties between 2011 and 2020 (SVTC). Moreover, during the first phase of variety development after independence, most of the wheat varieties were introduced from Russia (47) and other countries (32), whereas at the later stage, most registered varieties were from national breeding programs – showing the progressive changes in Uzbekistan's varietal portfolio. It's interesting to note most wheat varieties are from the public sector and for irrigated environments. Though limited, it's also encouraging to see few varieties released for rainfed environments (22). It's even more interesting to see a few (5) varieties released

by the private sector showing that its participation in varietal release is taking baby steps limiting its growth.

Uzbekistan follows a compulsory variety release and registration system. All advanced promising lines of wheat varieties developed by the national breeding programs and varieties introduced by foreign seed companies are submitted to the State Variety Testing Commission (SVTC) for testing and release. All such varieties are subject to two sets of tests, namely distinctness, uniformity, and stability (DUS) and value for cultivation and use (VCU). A variety failing any of these tests is not registered in Uzbekistan. The VCU tests evaluate varieties for performance. The results of the DUS tests are for granting breeder's rights protection (if requested by the breeder). Variety registration and performance testing are conducted by STVC for official recommendation to be grown in the country. SVTC has an extensive network of 12 state variety testing experimental stations and 36 special state variety testing sites, across the country. These represent different agro-ecologies and constraints in wheat production. The tests, which previously focused on cotton and other industrial crops, are now expanded to include cereals and legumes. This enables identification of varieties with wider or specific adaptations as varieties are released in regions or provinces. Given the limited physical and human resources, it's worth rationalizing the need and effectiveness of such a large network of sites and its implications for physical, financial, and human resources to manage the system.

Variety registration and release are considered public sector services fully funded by the Government – i.e., all costs are covered by SVTC. The absence of a variety testing fee is encouraging many national and foreign breeders to submit several varieties. While this is generally good, it may put pressure on the country's limited testing capacity. There's currently a discussion to charge variety testing fees, particularly for foreign breeders and private companies to address this.

SVTC maintains the list of released varieties as per the Regulation for National Catalogue of Agricultural Crops Registered for Cultivation in Uzbekistan (2019). However, exclusion from the register occurs if the:

(i) Variety does not correspond to its description

(ii) Variety lose its value for cultivation

(iii) Registration fees are not paid for maintaining the variety in the register

(iv) The variety is not used for more than four years

(v) Applicant requests it.

Legal persons (individuals or institutions) that disagree with SVTC decisions have the right to appeal them as established by the legislation.

Uzbekistan enacted a Law on Breeding Achievements that regulates the intellectual property rights and provides legal basis for PVP to encourage private sector participation in agricultural research and development. However, there are several critical challenges in scope and implementation:

- The current practice of IPR protection tries to apply the industrial inventions to plant variety protection where the concepts of patents, trademarks, etc. may not equally apply in practical terms.
- Fragmented functions between SVTC (technical) under MoA, and the SIPA (legal) under MoJ renders enforcement of PVP ineffective.

Moreover, the law contains several provisions which do not conform to those of the UPOV Convention where Uzbekistan is a member:

(i) The scope of the national law includes animal breeds while UPOV Convention covers only plant varieties

(ii) Most definitions of the national law do not correspond to the UPOV Convention

(iii) The law uses IPR concepts such as patents and license agreements that should be substituted by a UPOV-based system of priority rights and notification.

The plant variety protection law requires revising to align with the UPOV Convention to conform with international norms and standards to which the country is a member. It would also be advisable to designate one entity with the capacity to lead the PVP, and ensure its effective enforcement, or merge it with an agency responsible for variety release and registration. This will ensure release and PVP enforcement competencies lie in one authority (SVTC of MoA) and lets SIPA (MoJ) focus on non-agricultural IPRs to avoid complication.

According to the law, breeders (authors) and co-authors of the variety can be issued either a patent (SIPA) or a certificate (SVTC) and can enjoy the protection of the right for a designated variety. Practically, there's no variety licensing system in the country, but a royalty payment system established by the Government where a grain production joint stock company (Uzdonmakhsulot) – a public seed processing and marketing arm of the Government – can collect up to 3% of total certified seed sale value. Payments are distributed through the agricultural research system (previously through RICLC,) and are allocated as follows:

- Honorarium for breeders, co-authors, and seed specialists (10%) as an incentive.
- Payments to national (30%) and regional (50%) agricultural research offices to strengthen breeding, seed production, facilities and technical capacity.
- Seed production farms (10%) to strengthen the human resources capacity (training seminars, preparation manuals).

The royalty collection and payment processes are long and controlled by the public sector (GPC, SPC, RICLC). They are marked by unnecessary bureaucratic delays and require significant improvement.

Production of seed for candidate varieties submitted for testing to SVTC are expected to be undertaken based on the seed production scheme described in Chapter 4. Breeders should simultaneously begin preliminary seed multiplication to bulk enough quantity of seed to immediately enter large-scale commercial production on release of a variety. This

approach links varietal release with commercialization and would overcome the time lag between releasing a variety and availability of seed for farmers to cultivate them in their fields. Typically, this is often a major bottleneck in many developing countries. However, in practice, plant breeders do not give due attention to maintaining their varieties, limiting the availability of early generation seed. This is crucial for commercialization of new varieties and needs to be strengthened by the agricultural research institutes.

7.5 Seed production, commercialization and quality assurance

Since independence, Uzbekistan has developed several policies and strategies, laws and regulations, presidential and ministerial decrees, and institutional reforms for better governance. The primary objective of these strategic, policy, and institutional changes was to transition the agricultural sector in general, and the seed sector in particular, towards a market economy. Currently, however, the wheat seed sector is under a state monopoly where all production, processing, storage, and distribution are centralized, planned and operated by Government. Early generation seed production (super elite, and elite) is carried out through state agricultural research institutes on experimental farms or research centers, whereas the certified seed production (R1-R2) is carried out through the Grain Production Department on contract with public or private elite seed farms under the Government quota system. The elite seed farms sell their quota of certified seed out of their total production at prices offered by the Government. This is one by a quota system to the Grain Production Company, which is responsible for processing, storage, and distribution to farmers. The elite seed farms are allowed to sell any excess produce to the Government at a relatively higher price.

The Seed Development Center (SDC), an executive arm of MoA, is responsible for formulating policies and guidelines for the national seed system (see Figure 1.1) and coordinated with Government officials at national, district and local levels to determine seed production targets. It then ensures targets are met in coordination with the quality assurance program. Such a centralized operation, with no room to maneuver, stifles private sector participation (except in contract seed production) and growth, contrary to Government policy to liberalize and diversify the seed sector.

As outlined above, the Government's quota system, which is characterized by central planning, ensures all wheat area under production is covered by certified seed from improved varieties every year. Such an arrangement, raises various questions:

(i) Do the improved varieties produced and marketed align well with farmers' preferences? Do farmers have a say in using varieties other than those allocated to them?
(ii) How inclusive and transparent is the planning and implementation of the quota system?
(iii) Does the seed quality produced fully meet the standards set by the national regulatory agencies? How are issues of mixing managed as they may arise due to the way Grain Production Joint Stock Company carries out its responsibility to process both grain and seed?

(iv) How effective is the system at varietal replacement rates? How quick are new varieties made available on the market? Are there trend analyses of varieties in the market farmers can use to make informed decisions?
(v) Is such a high seed-replacement rate justifiable for a self-pollinating wheat crop? Is there any justification regarding seed quality constraints that warrants yearly replacement?
(vi) How does the system perform for efficiency and efficacy? Are there ways to improve both?

From 2011-2019, the total wheat area and quantity of certified seed produced for irrigated and rainfed areas showed little change, although the number of released varieties, particularly of bread wheat, increased from 11 in 2011 to 37 in 2019. Meanwhile, those for rainfed remained constant at about seven varieties. Over the years, there have been some changes in the mix of varieties where few old varieties were replaced by new ones. Krasnador-99, Tanya, Moskovich, Kroshka and Chillaki have remained dominant varieties in seed production over these years, although their share continues to decrease. Since 2016, new improved varieties such as Grom, Asr, and Yaksart are increasingly replacing the old varieties for seed production. The production of seeds of Yusa, Vassa, and Gozgoan appeared to be increasing from 2018 onwards, showing a clear shift in the seed production and wheat production landscape.

According to data from 2018, however, Grom constitutes about 14.9% of certified wheat seed production and covered about 14.7% of wheat area. This was followed by Krasnodar 99, Asr, Tanya, Gozgan and Vassa for certified seed produced and area of wheat covered. The top five bread wheat varieties constitute about 45.1% of certified seed production and 44.6% of total wheat area. This matches well with the wheat varietal adoption in farmers' fields where newer varieties are reaching them. Unlike countries such as Morocco, where very few mega wheat varieties dominate wheat production, there is relatively higher varietal diversity (about 24.88 per million ha) in the wheat fields of Uzbekistan which is not too far below countries such Turkey which are known to be hubs of wheat diversity. This is also evident with the higher number of varieties (43) for which certified seed is being produced in Uzbekistan.

The Government policy on seed production was first introduced in 1996, but was never implemented due to drastic changes in the overall economic policy towards import substitution and protectionist trade policy as described in previous chapters. Since 2015, there were gradual changes in agricultural policy to diversify the sector and reduce the Government monopoly in trade of agricultural production including seeds. However, major constraints remain to transforming the seed sector:

- The Grain Production Joint Stock Company (Uzdonmakhsulot) is a Government agency with a monopoly on procuring, processing, and distributing agricultural commodities of both grains and seeds through exclusive rights from variety owners. Lack of distinction in assigning responsibilities for seed and grain operations and current practices do not reflect seed production norms. This

leads to higher chances of varietal and seed mixtures and hence a reduction in seed quality.

- The Government quota system and centralized planning makes seed marketing irrelevant as it's distributed rather than marketed. Seed distribution is poorly regulated with no legal measures or enforcement mechanisms in place for non-compliance with the rules on seed quality distributed to farmers.
- The Seed Development Center and the agricultural research institutions are mostly a legacy from the Soviet era and their operations are not aligned well with international norms and reference standards. They're technically outdated and don't address the agriculture sector's current challenges and needs in general, or the national seed system's in particular. Moreover, the infrastructure for agricultural research and facilities for seed production, processing, and storage are antiquated and need replacing to ensure quality and timely operations.
- In most cases, plant breeding institutions (producing breeder and foundation seeds) and elite farmers and state farms (producing seed) don't have enough infrastructure, funding or human resources capacity to produce high-quality seed.
- There's no well thought out system for estimating seed demand to guide seed production and marketing. Particularly, there's no systematic approach to match varieties and their recommended (or better yet their demand) domains.

Currently, almost all wheat area is covered by certified seed based on a Government plan where several varieties should be produced and marketed. These involve different public organizations which can be inherently inefficient and bureaucratic. This arrangement may put a huge and unnecessary burden on the whole country's physical, financial and human resources need for certified seed production and processing. This is more so because seed experts recommend seed replacement rate of at least 25% (once every four years) casting doubt on the efficacy of the current annual varietal replacement in Uzbekistan. The absence of a system to rationalize the scheme, and reform it within acceptable limits, may be what is impeding the availability of varieties with specific quality traits and hence farmers' access to quality seed.

Recently, the Government embarked on privatizing public seed farms to become private seed enterprises or grain production farms. As a result, it has introduced a clustering system. The seed clusters include seed producers, seed processors, and seed sellers, who previously worked independently in the existing production system. This initiative has started in five provinces and will expand to others in the coming years if the first seed clusters prove successful.

In Uzbekistan, seed quality assurance and certification is compulsory. All seed producers need to be registered, all seed production fields inspected, and all seed tested. Until 1995, the State Seed Certification and Quality Control Center which was under the MoAWR was responsible for seed quality assurance and certification of agricultural crops. Currently, the Department for Control of Agricultural Crop Seed Production, under State Inspectorate of Agro-industrial Complex (accountable to the Cabinet of Ministries)

is responsible. The Department for Control of Agricultural Crop Seed Production has an extensive network with an inspectorate of 13 provincial offices and 122 district representatives. It also has regional official seed testing laboratories in almost every province (and sometimes at district level). However, critical constraints remain:

- The seed certification scheme uses different seed classes, which are acceptable nationally, but do not conform to international nomenclatures. Moreover, the same old field inspection manual and seed testing manuals from FSR are still used and don't conform to international norms.
- The national field and seed standards are high and difficult to achieve by most seed producers, leading to a large quantity of good-quality seed being rejected. There are problems with quality of certified seed due to varietal mixtures, poor physical quality (damaged or shriveled seed), or low germination due to:

  (i) Limited capacity of technicians in seed quality assurance in seed sampling and seed testing
  (ii) Obsolete and poorly maintained cleaning machines, with damaged screens for proper seed cleaning
  (iii) Handling of raw seed with food grain that could hinder the traceability of seed lots and the potential for the mixing of seed and grain during processing and storage.

Each year in May, the Ministry of Agriculture adopts a decree to establish a wheat field inspection committee at national, provincial and district levels. Members include representatives from MoA, SIAC, SDC, Uzbek Agriculture Chemical Protection Agency, Council of Farmers, small farms and private households. This mobilizes 610 field inspectors from these institutions. Certified seed fields are usually inspected by authorized inspectors at all levels of the field inspection committee. It is important to monitor in terms of ensuring the effectiveness and efficiency of the quality of seed certification process.

The central seed laboratory is well-equipped to undertake a comprehensive seed testing program in the country and received accreditation from Uzbek Standard Agency. However, only Khorezm and Karakapkastan have been accredited from the provincial laboratories. Strengthening the human resources capacity and equipment of all seed testing laboratories is essential.

7.6 Seed demand, adoption and impact

A national survey of 1,526 households was carried out in eight provinces, covering over 70% of wheat area and 62% of wheat production in the 2012/13 cropping season. During the survey, 41 wheat varieties were found in farmers' hands. Varieties released 15, 10, and 5 years before 2012/13 were cultivated by 94.1%,82.5%, and 59.1% of all Uzbek farmers on 96%, 82%, and 58%, respectively of total national wheat area.

The top 10 varieties were cultivated by 79.9% of growers and covered 81.3% of the area.

Six of the top 10 varieties were released after 2006 and grown by 69.2% of farmers on 70.3% of total cultivated wheat area. The top two varieties by number of growers are Tanya (released in 2010 and cultivated by 33.9% of farmers on 26.3% of the total wheat area) and Krasnovodopadskaya99 (released in 2008 and cultivated by 15.5% of farmers on 21.0% of the total wheat area) with a combined adoption rate of 49.4% of all Uzbek wheat farmers and covering 47.3% of total national wheat area.

Based on the survey results, the area-weighted varietal age in 2012/13 for all eight and the three revisited provinces was 7.6 and 9.9 years, respectively. In contrast, the area-weighted varietal age in 2016/17 in the three revisited provinces was 6.6 years. This shows in these three revisited provinces, varietal turnover was 33% faster in 2016/2017 than in 2012/13 – showing substantial progress. Assuming the situation is the same across the country, our estimates of the weighted average age of varieties is less than the 8-10 years reported by Lantican et al., 2014.

Adoption of improved wheat varieties in terms of the number of farmers and area coverage varies across provinces, between large and small farmers, and by variety ages. Among all Uzbek provinces, the highest adoption for varieties of 15 years or less was seen in Jizzakh, and Samarkand where 100% of their respective total provincial wheat areas were covered by 15 years old or less varieties. The lowest adoption was seen in Tashkent (81%) and Andijan (92.2%). Regarding the area coverage of the most recent varieties (released in the previous five years), the top three provinces were Navoi (79.7%), Jizzakh (73.1%), and Karakalpakstan (71.5%).

Among the most important determinants of adoption are size of cultivated crop land, years in education for the household head, hosting demonstration trials on farmer's own farm, and access to credit. Based on the 2016/17 data, adopting improved wheat varieties led to 1353.86 kg/ha (25.5%) increase in yields, 367,364 UZS or 129.3 USD (25.1%) higher net income per ha, and a 22.3 kg/capita/year (32.7%) increase in wheat consumption. Given the estimated 79.2% adoption degree in 2016/17 for less than 10 years old varieties, Uzbekistan produced about 1.54 million metric tons (25%) additional wheat, 2.1 trillion UZS (0.74 billion USD) extra wheat income, and 46.6kg/capita/year (31.7%) extra wheat available for consumption.

7.7 The way forward

The study on wheat seed systems, adoption and impacts may raise many more questions than answers. It may challenge the orthodoxy or dichotomy of two schools of thought. Namely, the command or liberal economy. While most of us argue and advocate for a more liberalized and diverse seed systems, the series of three studies, including this one that represents different levels of seed system diversity and varying levels of formulation and implementation of seed laws, show the political, social and economic development path may also shape the feature and future of the national seed sector. For varietal turnover, Uzbekistan showed a varietal replacement rate of 7.6 years (in 2012/13), which is faster than more liberal systems in other countries such as Turkey

(20 years) and Morocco (22 years). In other publicly dominated seed systems, varietal replacement is low making the issue even more complex. Comparing the situation in different countries, with centrally controlled seed systems and other market-oriented countries, might help to draw important lessons for mutual learning, knowledge sharing, and developing seed systems in each country.

While the fast varietal replacement rate in Uzbekistan is encouraging, what is not known is whether farmers are getting the best possible varieties that can either be made or which are already available in the system. This will require comparing traits of varieties on the varietal menu made available for the Uzbek farmers with those in the varietal release catalogue, as well as with the traits of best varieties under cultivation in similar countries in the region.

To enhance the efficacy of the Uzbek seed sector, several interventions are needed:

1) Seed production should be guided by supply and demand. Although seed production is centralized, there's a mismatch between production and demand of varieties. It's critical to have information about the seed market, including seed production and sale in each region, and seed imports. This information is necessary for farmers to make better informed decisions.
2) It's important to closely monitor the performance of the new clustering approach for seed production and draw lessons to guide future changes to make clusters more efficient and replicable in remaining provinces.
3) It is necessary to introduce a dynamic and rigorous evaluation system to check how compatible breeding objectives and farmers' trait preferences are, and whether the yields of the most recent varieties are high enough.
4) It is necessary to improve the capacity, in particular, the physical resources of plant breeding institutions (producing breeder and foundations seeds) and elite farmers and state farms producing certified seed.
5) It is important to analyze and identify the traits desired by different parties in the wheat value chain (farmers, millers, bakeries, consumers, etc.) and strengthen the promotion and commercialization of the new improved varieties and associated technologies.
6) Wheat seed production must ensure high-quality seed of adapted varieties is available and accessible to all farmers in areas where varieties are suitable.
7) It would be highly desirable to standardize seed classes, review procedures and manuals, and develop a training program to strengthen the capacity of staff for seed quality control and certification.
8) To address the issues related to the quality of certified seed, the following measures need to be introduced:
    a. Enhancing the capacity of technical staff in seed quality assurance particularly in seed sampling and testing.
    b. Providing adequate infrastructure for seed processing.

c. Assigning responsibilities for processing seeds and grains to separate institutions. If this isn't possible, it's important to handle raw seed separately from food grain. This enhances traceability of seed lots and avoid mixing seed and grain during processing and storage.

9) Arranging annual inspections of certified seed fields by authorized inspectors of members of the field inspection committee at all levels is a good way to mobilize local resources. However, it should be supported by strong capacity development to ensure the reliability and uniformity of inspection procedures in all fields.

10) All the seed testing laboratories in all provinces other than Khorezm and Karakapkastan need a major overhaul of facilities and staff training in new seed testing methods, procedures, and guidelines, ultimately, leading to accreditation by the Uzbek Standard Agency.

11) Currently, statistical information in the agricultural sector in general, and in the seed sector in particular, is not available in the public domain. Efforts should be made to make all relevant information accessible via a database, like the national database of legislation of the Republic of Uzbekistan.

The agricultural development policy for achieving food security and economic development enabled rapid progress in the wheat sector. Production of wheat is all about food security, which makes it politically sensitive. Wheat is part of the state-regulated production system, so any reform will require strategic thinking, careful consideration of pros and cons, and setting of priorities. In particular, replacing the current regulated system with fully market-oriented arrangements will not be easy, as it requires making major changes in the overall agricultural policy, and therefore may take a long time.

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Annexes

Annex 1. Bread and durum wheat varieties released in Uzbekistan (1942-2019)[20]

Application number	Variety name	Country of origin	Release year	Remarks
Bread wheat				
2000245	Andijon 1	Uzbekistan	2008	
2000247	Andijon 2	Uzbekistan	2003	
2000246	Andijon 4	Uzbekistan	2004	
2007375	ASR	Uzbekistan	2013	
2008438	Bardosh	Uzbekistan	2015	Private
1997227	Bahmal 5	Uzbekistan	2012	
2002268	Bobur	Uzbekistan	2006	
2014473	Brigada	Russia	2019	
2010420	Vassa	Russia	2016	
2006357	Vostorg	Russia	2010	
7801734	Grekum	Uzbekistan	1983	
2010418	Gratsiya	Russia	2013	
2010419	Grom	Russia	2013	
2007368	Garezsizlik	Uzbekistan	2019	
2010416	Gozgon	Uzbekistan	2018	2015*
2006347	Davr	Uzbekistan	2019	
2003316	Denov	Uzbekistan	2008	
2001258	Dostlik	Uzbekistan	2005	
2001259	Durdona	Uzbekistan	2009	
2008381	Esaul	Russia	2011	
2014460	Yogdu	Uzbekistan	2019	Private/2016*
2002279	Jayhun	Uzbekistan	2007	
2011427	Jasmin	Uzbekistan	2016	Private
2010424	Zvezda/Yulduz	Russia/Uzbekistan	2016	
2010421	Zimnitsa	Russia	2015	
7400861	Intensivnaya	Kyrgyzstan	1981	
2011432	Istiqlol	Uzbekistan	2017	
2011433	Istiqlol	Uzbekistan	2019	
2014470	Kalym	Russia	2019	
7200579	Krasnovodopadskaya 210	Kazakhstan	1980	
2005341	Krasnodarskaya	Russia	2008	
9400167	Ko'kbulak	Uzbekistan	2001	
2006354	Kuma	Russia	2010	
9800233	Kroshka	Russia	2000	
2013444	Lebed	Russia	2019	2016*
2002283	MARS	Uzbekistan	2006	

[20] *Source: SVTC 2020 personal communication*

Application number	Variety name	Country of origin	Release year	Remarks
2006344	Matonat	Uzbekistan	2010	
2006355	Moskvich	Russia	2010	
2006359	Nota	Russia	2010	
8900590	Oq bug'doy	Uzbekistan	1993	
2003327	Omad	Uzbekistan	2012	
2006358	Pamyat	Russia	2010	
2010422	Pervitsa	Russia	2018	
2010408	Rapsodiya	Serbia	2013	
8400164	Sanzar 6	Uzbekistan	1990	
8603723	Sanzar 8	Uzbekistan	1991	
2003318	Saidaziz	Uzbekistan	2010	
2013446	Sila	Russia	2018	2015*
2001270	Starshina	Russia	2004	
2014467	Tabor	Russia	2019	
2006356	Tanya	Russia	2010	
7601263	Tezpishar	Uzbekistan	1980	
2013447	Termiz 5	Uzbekistan	2019	
2007373	Turkiston	Uzbekistan	2011	
2013448	Farboma	Uzbekistan	2019	Private
2000249	Chillaki	Uzbekistan	2002	
9200053	Hosildor	Uzbekistan	1996	
2014471	Yuka	Russia	2019	2016*
2009400	Yaksart	Uzbekistan	2014	
9100628	Yanbash	Uzbekistan	1995	
9600059	Gardens	Egypt	1997	
3700054	Surhak	Tajikistan	1942	
2005063	Bahor-1	Uzbekistan	2013	
Durum wheat				
2006353	Javohir	Uzbekistan	2011	
9600186	Karlik	Uzbekistan	2000	
2000252	Kahrabo	Uzbekistan	2007	
2009405	Krupinka	Russia	2012	
7000529	Leukurum 3	Uzbekistan	1976	
9800236	Leukurum 21	Russia	2000	
9003266	Marvarid	Uzbekistan	1998	
8900035	Makuz 5	Uzbekistan	2000	
2012457	Mingchinor	Uzbekistan	2017	
1994180	Istiqlol	Uzbekistan	2019	
2006064	Istiqbolli	Uzbekistan	2018	Private

*Note: *Provisionally released in this year*

Annex 2. List of released varieties categorized by agronomic and grain quality traits (1942-2019/2020) [21]

Serial no.	Variety	Year registered	Year un-registered	Winter bread/durum wheat	spring bread/durum wheat	Irrigated/rainfed	Country code	Yield (t/ha)	Bread score	Gluten content (%)	Hardness (%)	Gluten deformation measurement	Test weight (g/l)	Protein content (%)	Cold tolerance (1-10)	Salt tolerance (1-10)	Lodging resistance (1-10)	Yellow rust tolerance	Brown rust tolerance	Days to maturity (days)	TKW (g)	Plant height, (cm)
1	Marvarid	1998		Durum		rainfed	UZ	15.0-21.7	4	31.2				16.2	5	4	5	90		160-180	38.7	75-80
2	Kroshka	2000		Bread		irrigated	RU	41.0-52.4	4-5	31				11.5-13.7	5	4	5	85		210-220	38.3-47.5	75
3	Karlik-85	2000		Durum		irrigated	UZ	45.4						13.5	5	5	5			181-200	38.4-45.8	75-85
4	Leukurum 21	2000		Durum		irrigated	RU	38.0-48.3						11.2	4-5	4-5	5	80		210-220	39.0-45.0	75-85
5	Makuz 3	2000		Durum		irrigated	UZ	45.1/25.1						12.1	5	4-5	4-5			180-200	38.4-39.1	75-85
6	Yuna	1998	2000	Bread		irrigated	RU	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
7	Intensivnaya	1981		Bread		irrigated	KRG	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
8	Krasnovadopad 210	1980		Bread		rainfed	KZ	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
9	Siett Serros -66	1977		Bread		irrigated	MX	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
10	Spartanka	1998	2000	Bread		irrigated	RU	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
11	Gorlitsa	1999	2000	Bread		irrigated	RU	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
12	Ophelia	1999	2000	Bread		irrigated	RU	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
13	Ko'k buloq	2001		Bread		rainfed	UZ	15.1-19.1	3.8	25				9.8	4	3	4	84		147-177	38.9-45	70-80
14	Chillaki	2002		Bread		irrigated	UZ	42.8-61.6		30		95		12.2	4-5	4-5	4-5	100	20	198-212	42.0-44.0	85
15	Ulugbek 600	1998	2002	Bread		irrigated	UZ	59-60		34			690-790	11.7-13.8	5	3	5	85		226-258	44.0-45.0	80-90
16	Dobraya	1998	2002	Bread		irrigated	UZ	44.8-52.6	4.5	27			724	11.6	5	3	5	40	20	180-207	42.2-44.0	80-90
17	Demetra	1999	2002	Bread		irrigated	RU	40.0-54.0	4.5-5	25				14	5	4	5	75		230-255	37.0-44.0	80-90
18	Skifyanka	1998	2002	Bread		irrigated	RU	36.0-47.3	4.4	35			703	16	5	4	5	83		216-226	36.4-41.0	80-93
19	Giza 164	1997	2002		Bread	irrigated	EG	22.4-31.0						9.1	×	3	5			82-93	35.7	70-75
20	Sads 2	1997	2002		Bread	irrigated	EG	38.2						9.3	×	4	5	90		80	35.7	86
21	Saxa 8	1997	2002		Bread	irrigated	EG	26.2						9.5	×	3	5			90-93	37.2	75
22	Saxa 69	1997	2002		Bread	irrigated	EG	24.6						9.1	×	4	5			80-93	33.0-35.0	80
23	Prima Odesskaya	2004		Bread		irrigated	UA	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
24	Krasunya Oddeskaya	2004/2005		Bread		irrigated	UA	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
25	Shavkat	2005/2006		Bread		irrigated	UZ	42.2-63.8		24		100		14	4-5	4-5	4-5			203-228	41.7-45.8	85-95
26	Qahrabo	2006/2007		Durum		irrigated	UZ	43.3-59.4		28		95		12	4-5	4-5	4-5	94		204-227	39.2-43.7	80-85
27	Pal Pich	2006/2007		Bread		irrigated	RU	51.5	1.0-2.0	26		115		13.5	5	4	4-5			249	41.3	75-85
28	Alexandrovka	1991	2007	Durum		irrigated	UZ	22.9/51.3	4	36				18.2	5	5	5	86		204-220	42	80-85
29	Denov 1	2007/2008		Bread		irrigated	UZ	52.1-58.5	4	28		95		16.1	5	4	4-5	95		205-212	36.8-42.6	75-100
30	Krasnodarskaya 99	2006/2007/2008		Bread		irrigated	RU	45.2-62.9	4	28		80		14.2	5	5	5			186-205	43.0-43.8	100-112

Note: Varieties for which multiple years for registration are indicated show that they were provisionally released before final registration.

[21] *Source: SVTC 2020 (personal communication)*

Serial no.	Variety	Year registered	Year un-registered	Winter bread/durum wheat	spring bread/durum wheat	Irrigated/rainfed	Country code	Yield (t/ha)	Bread score	Gluten content (%)	Hardness (%)	Gluten deformation measurement	Test weight (g/l)	Protein content (%)	Cold tolerance (1-10)	Salt tolerance (1-10)	Lodging resistance (1-10)	Yellow rust tolerance	Brown rust tolerance	Days to maturity (days)	TKW (g)	Plant height, (cm)
31	Boz suv	2002	2009	Bread		irrigated	UZ	46.6-52.1	3	26		115		10.5	5	3	5	90		216	40.0-44.9	80
32	Uzbekistan 1	2003	2009	Bread		irrigated	UZ	43.1-52.6	4	27		105		13.1	4	4	4	80		205-210	42.3-44.9	85
33	Unumli bugdoy	1983	2009	Bread		irrigated	UZ	47.3-49.8	5	26			650	11.3	5	3	4	90		204-225	40.6-43.4	75-85
34	Saidaziz	2007/2010		Bread		irrigated	UZ	52.0-57.0	3	26		90		13.1	5	4	5			210-229	40.0-40.5	90
35	Kuma	2007/2008/2009/2010		Bread		irrigated	RU	43.0-59.0	2.0-4.0	23		95		14.6	5	5	5			209-218	40.9-42.2	85-95
36	Tanya	2007/2008/2009/2010		Bread		irrigated	RU	42.7-58.3	2.0-4.0	26		100		16.2	5	5	5			211-218	38.9-42.8	90-100
37	Vostorg	2007/2008/2009/2010		Bread		irrigated	RU	37.4-57.	2.0-3.0	26		95		15	5	4	5			203-211	40.2-40.5	75-85
38	Note	2007/2008/2009/2010		Bread		irrigated	RU	32.0-56.0	2.0-3.0	28		95		13	5	4	5			210-230	33.0-38.0	75-95
39	Illora	2007	2010	Durum		irrigated	GR	46.6						9.1	5	3	5			190	42	75-86
40	Arakena	2007	2010	Durum		irrigated	GR	47.4						10.3	5	3	5			190	41.5	90
41	Javoxir	2010/2011		Durum		rainfed	UZ	10.3-19.9	4.5	28				15.2	5	4-5	4-5			192-198	36.9-39.6	75-85
42	Esaul	2010/2011		Bread		irrigated	RU	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
43	Bayovut 1	2011		Bread		irrigated	UZ	52.4		23	32	55	739	12.3	5	5	4-5	80	10	214	49.7	70-80
44	Berdun	2010/2011		Bread		irrigated	FR	38.6-57.2						13	5	5	5			218-232	35.8-45.0	75-85
45	Apash	2010/2011		Bread		irrigated	FR	40.1-58.2						16	5	5	5			213-232	34.6-44.2	75-85
46	Marjon	1996	2011	Bread		irrigated	UZ	43.6-57.6	3	30		100		16	4-5	4-5	4-5	80		189-230	41.0-52.5	75-85
47	Gayrat	2002	2011	Bread		irrigated	UZ	42.6-57.0	3	24		110		10.5	4-5	4-5	4-5			218-220	36.7-44.0	75-80
48	Madaniyat (Buxoroi Sharif)	2004/2005/2006	2011	Bread		irrigated	UZ	42.6-71.6		23		110		13.2	4-5	4-5	4-5	93		188-205	42.1-51.0	90
49	Gavxar	2006/2007	2011	Bread		irrigated	UZ	39.9-58.7	2	29		100		14.2	5	4-5	5	95		199-226	40.8-41.7	85
50	Giza 163	1997	2011		Bread	irrigated	EG	41.3						11	×	5	5			82-92	35	82-92
51	Baltazar	1999	2011	Bread		irrigated	FR	52.5-55.1	4	27			682	12.4	5	3	5			215-229	41.0-44.5	75-85
52	Suasson	1999	2011	Bread		irrigated	FR	51.7-59.4	3.8	26			668	12	5	4	5			210-220	41.5	70-75
53	Mv-16	1999/2002	2011	Bread		irrigated	HU	48.7	4.2	28			700	13	4-5	4-5	4-5			181-225	37.0-40.1	75-86
54	GK-Kata	1999/2002	2011	Bread		irrigated	HU	47.4-56.5	4	28			682	11.8	5	3	5			225	41.5	70-85
55	Tribor	2000/2002	2011	Bread		irrigated	FR	49.4-57.6	4	27				13.6	5	4	5			207-220	39.0-43.8	90
56	Exo	2002	2011	Bread		irrigated	RU	46.9-57.0	2	28		100		14.7	5	5	5	90		208-224	39.1	81
57	Yugtina	2002	2011	Bread		irrigated	RU	52.4	2	30		80		12.6	5	5	5			178	40.1	83
58	Delta	2002	2011	Bread		irrigated	RU	49.5-53.6	3	27		95		12.6	5	4	5			210-220	36.6-39.0	84
59	Krasota	2003	2011	Bread		irrigated	RU	53.9-64.8	2	28		90		12.4	5	5	5			187-210	36.6-39.0	85
60	Guadelupe	2004/2005	2011	Bread		irrigated	FR	61	2	28		100		13.7	5	5	5			165-170	41.1-43.2	70-75

Serial no.	Variety	Year registered	Year un-registered	Winter bread/durum wheat	spring bread/durum wheat	Irrigated/rainfed	Country code	Yield (t/ha)	Bread score	Gluten content (%)	Hardness (%)	Gluten deformation measurement	Test weight (g/l)	Protein content (%)	Cold tolerance (1-10)	Salt tolerance (1-10)	Lodging resistance (1-10)	Yellow rust tolerance	Brown rust tolerance	Days to maturity (days)	TKW (g)	Plant height, (cm)
61	Selyanka Krasnodar	2004/2005/2006	2011	Bread		irrigated	RU	55.4-58.3		28		100		16.2	4-5	4-5	4-5	90		190-203	39.4-41.0	90
62	Krupinka	2010/2011/2012		Durum		irrigated	RU	52.0-63.2		24		95		12.7	5	5	5			230-233	45.0-49.2	83
63	Shirin	2012		Bread		irrigated	UZ	41.4-68.7	1	29	55	100	671	16	5	3-4	5			201-217	41.5-42.6	84
64	Dragana	2012		Bread		irrigated	SR	53.6-73.0		32	36	95	701	11	5	5	5			196-229	38.0-42.0	85
65	Nefer	2010/2011/2012		Bread		irrigated	RU	47.3-68.3		23		95		13.2	5	5	5			220-228	41.3-52.0	80
66	Otan	2010/2011/2012		Bread		irrigated	FR	40.5-59.5		23		110		16.4	5	5	5			220-232	35.9-47.2	90
67	Sezan	2010/2011/2012		Bread		irrigated	FR	45.7-55.1		24		100		15.2	5	5	5			220-232	33.8-45.4	83
68	Bobir	2005/2006/2013		Bread		irrigated	UZ	48.7-61.7		27		100		12.3	4-5	4-5	4-5			202-215	41.0-44.5	85
69	Turkiston	2009/2010/2011/2013		Bread		irrigated	UZ	40.0-57.0	2.5	23		95		11.1	5	3	5			204-230	40.2-47.2	80
70	Bahor-1	2012/2013			Bread	irrigated	UZ	31.4-45.3						10.2	×	3-4	3-4			96-100	30.0-31.4	90
71	Grom	2012/2013		Bread		irrigated	RU	44.0-59.0	3	22		95		16.2	5	5	5			195-205	39.0-41.0	83
72	Gracia	2012/2013		Bread		irrigated	RU	39.0-54.0	2.5	24		90		15.6	5	5	5			195-205	39.0-40.0	84
73	Zamondosh	2013		Bread		irrigated	UZ	45.5-56.8	2.5	20	43	100	688	14.9	5	3-4	5			191-233	40.0-46.0	85
74	Pobeda	2013		Bread		irrigated	SR	52.0-71.0		32	36	100	701	15	5	3-4	5			197-225	38.2-41.3	80
75	Andijon 2	2003/2014		Bread		irrigated	UZ	45.0-58.3	3	28		95		11.3	5	3	5	80		205-237	39.2-46.5	90
76	Andijon 1	2004/2007/2008/ 2013/2014		Bread		irrigated	UZ	41.7-56.3	4	26		100		10.2	5	4	5	90		203-227	36.0-40.9	90
77	Mars 1	2005/2006/2014		Bread		irrigated	UZ	40.3-65.5		28		100		16.2	4-5	4-5	4-5	90		191-220	40.5-45.0	83
78	Surxak 5688	1942/2014			Bread	rainfed	TJ	18.6-19.6	3	22.5			696	11.3	×	4-5	4-5	84		80	37.2-43.5	70-75
79	Sanzar 6	2013/2014		Bread		rainfed	UZ	17.7-23.4	3	27			710	8.5	5	4	5	63	10	145-177	37.0-45.0	70-75
80	(Zamin 1) Jayxun	2004/2005/2006/ 2007/2013/2015		Bread		irrigated	UZ	43.6-61.5	2-3	24		100		14.3	4-5	3	5	70		210-224	40.0-50.0	75-85
81	Yaksart	2011/2012/2013/ 2014/2015		Bread		irrigated	UZ	30.0-55.0	2.5-3	25		80		13.2	5	5	5			200-225	40.0-41.3	76-83
82	Paxlavon (Emir)	2014/2015		Bread		irrigated	UZ	41.0-50.8		32	36	100	802	12.1	4-5	4-5	4-5	90		202-210	48.6-53.4	80
83	Saratovskaya 68	2010/2011/2015			Durum	irrigated	RU	32.8	3	32	55	95	686	15.1	×	4-5	5			100	29.1	75-85
84	Favorit	2010/2011/2015			Bread	irrigated	RU	22.8	3.5	32	54	95	676	14.2	×	4-5.1	5			107	21.7	75-90
85	NS-40 S	2011/2012/2015		Bread		irrigated	SR	42.8-62.0	3.5	26	47	105	685	16	5	5	5			206-210	40.5-43.4	75-90
86	Turakurgan - I	2004/2005	2015	Bread		irrigated	UZ	41.6-56.7	3	26		100		13.5	3-4	3-4	3-4	70		177-180	35.1-43.6	80
87	Nikoniya	2005/2006	2015	Bread		irrigated	RU	54.0-61.5		24		90		14.2	5	5	5			210-217	43.0-44.4	75-85
88	Kupava	1999	2015	Bread		irrigated	RU	40.5-54.2	4	28			780	12.5	5	4	5	40		220-255	40.0-46.0	76-83
89	Knyajna	2000	2015	Bread		irrigated	RU	42.2-55.8		26				12.9	4-5	4-5	4-5	80	5	190-247	40.2-43.0	80
90	Umanka	2000	2015	Bread		irrigated	RU	42.4-51.1						11.5	4-5	4-5	4-5	80	5	190-247	37.0-42.0	75-85

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91	Tezpishar	1980/2016		Bread		rainfed	UZ	15.6-21.8	3.5	27			750	9.1	5	4	5	78		143-177	36.3-40.7	70-80
92	Yanbash	1995/2013/2014/2016		Bread		irrigated	UZ	43.0-57.8	4.5	30			800	14.7	5	5	5	20	20	226-250	38.8-45.5	75-85
93	Durdona	2007/2009/2013/ 2014/2015/2016		Bread		irrigated	UZ	42.1-62.0	3	24		100		13.2	4-5	3	5			191-211	37.1-42.0	80
94	Matonat	2009/2010/2013/ 2015/2016		Bread		irrigated	UZ	38.5-52.0	2.5	23		95		13.5	4-5	4-5	4-5			209-223	38.0-42.0	80-85
95	Asr	2011/2013/2014/ 2015/2016		Bread		irrigated	UZ	38.-72.9	2.5					14.2	4-5	3	5			185-225	40.4-58.0	80
96	Baxmal 97	2011/2012/2016		Bread		rainfed	UZ	14.8-23						11.9	4-5	4-5	4-5			94/192	40.0-41.3	70-75
97	Jasmina	2014/2015/2016		Bread		irrigated	UZ	45.6-71.2	4	26	52	95	677	14.2	5	3-5	5			209-225	42.0-47.5	75-85
98	Raspodiya	2012/2013/2015/2016		Bread		irrigated	SR	46.0-71.0	3	25		95		15.6	5	5	5			198-215	39.5-41.0	90-100
99	Star	2013/2015/2016		Bread		irrigated	RU	39.2-64.1	3	19	40	125	801	16.1	5	5	5			210-225	39.0-49.0	90-100
100	Vassa	2015/2016		Bread		irrigated	RU	59.9-71.0	2	24	50	95	686	17	5	5	5			220-227	31.1-42.6	90-95
101	Emerald	2001	2016	Bread		rainfed	UZ	16.6-22.7	3	25				9.3	4-5	4-5	4-5	83		145-176	38.5-44.9	75-80
102	Istiqlol 6	2015/2017		Bread		rainfed	UZ	6.0-27.7		31	50	80	820	10.1	4	4	5			163-185	38.2-42.2	70-75
103	Kelajak	2011/2012/2015/2017		Bread		irrigated	UZ	51.2	2.5	29	46	105	747	14.1	4-5	4-5	4-5	60	20	212-218	38.5-39.3	70-75
104	Boz qala	2004/2006/2007	2017	Bread		irrigated	UZ	54.0-54.6	2	25		95		13.1	4-5	4-5	4-5	90		219-224	41.3-45.0	70-75
105	Polovchanka	1999	2017	Bread		irrigated	RU	63.4-64.0	4	25			730	11.8	5	5	5	80		220-258	38.0-43.0	75-85
106	Selyanka Odesskaya	2004/2005/2006/2013	2017	Bread		irrigated	UA	55.0-56.4		23		85		15.1	5	5	5	90		210-212	49.0-50.0	85-90
107	Fortuna	2010/2011/2012	2017	Bread		irrigated	RU	50.0-62.0		23		100		13.2	4-5	4-5	4-5			223-232	35.9-40.0	75-87
108	Andijon 4	2004/2013/2014/2018		Bread		irrigated	UZ	37.5-69.1	3	28		95		11.9	5	5	5	70		204-217	38.4-42.4	80
109	Dostlik (Galsim 96)	2004/2005/2013/2018		Bread		irrigated	UZ	47.6-64.1	2	27		100		13.1	4-5	4-5	4-5	75		209-222	40.2-44.4	90
110	Istiqbolli	2013/2018		Durum		irrigated	UZ	45.2						12	×	4-5	4-5			97-100	35.2	85
111	Gozgon	2015/2016/2017/2018		Bread		irrigated	UZ	41.2-61.1	2	38	46	100	876	13.6	5	4-5	5			196-229	36.4-43.9	90
112	Starshina	2004/2013/2018		Bread		irrigated	RU	54.5	2	28		100		12.2	5	5	5			186	40.4	80-95
113	Pervitsa	2014/2018		Bread		irrigated	RU	42.0-73.6	3	24	45	95	806	16.2	5	5	5			203-228	38.0-42.6	85-90
114	Sila	2015/2016/2018		Bread		irrigated	RU	38.2-54.7	2	29	42	100	774	15.4	5	5	5			202-234	39.6-48.4	86-93
115	Yorqin	2018		Bread		irrigated	UZ	39.3-52.1	4	28	50	90	803	11	5	3	4-5	90	5	211-221	39.3-44.0	75-80
116	Soqkhibkor (Muftallo)	2011/2015/2018		Bread		irrigated	UZ	43.4-55.3		23	28	65	721	12.3	4-5	3	4-5	80	10	203-219	40.7-47.0	75-85
117	Istiqlol	2002/2012/2019		Durum		irrigated	UZ	41.9-52.5						×	4-5	4-5	4-5			208-211	40.8-43.3	×
118	Garezsizlik	2011/2019		Bread		irrigated	UZ	38.5						×	5	5	5			230	39.1	×
119	Bardosh (Ravi)	2014/2015/2019		Bread		irrigated	UZ	51-68.5		24	43	80	800	×	5	5	5			203-230	38.5-41.2	×
120	Istiqlol 20	2015/2017/2018/2019		Bread		irrigated	UZ	49.7-77.9	3	30	48	90	787	×	5	4-5	4-5	90		207-217	36.8-50.2	×

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121	Termiz 5	2016/2017/ 2018/2019		Bread		irrigated	UZ	42.0-76.1		28	42	100	776	×	3-5	4-5	4-5			203-213	40.0-40.5	×
122	Yogdu	2016/2019		Bread		irrigated	UZ	47.0-61.4		26	28	80	742	×	4-5	4-5	4-5			203-219	39.5-43.0	×
123	Davr	2016/2019		Bread		irrigated	UZ	44.0-65.0		26	11	80	714	×	4-5	4-5	4-5			202-218	37.3-51.4	×
124	Farboma	2017/2019		Bread		irrigated	UZ	48.3-54.5		32	42	80	786	×	4-5	4-5	4-5			206-215	40.0-57.1	×
125	Yuka	2016/2019		Bread		irrigated	RU	36.2-69.1		28	30	80	808	×	4-5	4-5	4-5	95		202-232	37.2-43.6	×
126	Lebed	2016/2019		Bread		irrigated	RU	35.1-52.0	3	21	37	60	784	×	4-5	4-5	5			210-229	35.4-42.0	×
127	Brigade	2016/2019		Bread		irrigated	RU	40.4-58.8		28	39	80	779	×	4-5	4-5	5			205-229	37.3-42.8	×
128	Tabor	2016/2019		Bread		irrigated	RU	31.5-55.2	4	29	41	60	761	×	5	5	5			210-229	35.4-42.0	×
129	Kalym	2016/2019		Bread		irrigated	RU	37.3-56.4		27	38	95	750	×	4-5	4-5	4-5			203-229	35.6-43.0	×
130	Oq marvarid	2019		Bread		????/????	UZ	46.3-47.5	3	33	60	95	791	×	5	3	4-5			204-205	45.5-48.7	×
131	Fergana	2019		Bread		irrigated	UZ	55.7-59.1	3	32	39	90	727	×	5	3	4			208-210	40.2	×
132	Zilol	2019		Durum		irrigated	UZ	40.0-71.0		26	33	90	787	×	4-5	3-4	4-5			203-219	40.0-43.6	×
133	Shortanbay-1	2019		Bread		irrigated	UZ	40.0-43.0		24	43	80	800	×	5	5	5			226-236	41.0-43.0	×
134	Oltin bugdoy	2019		Bread		irrigated	UZ	43.7-74.9		24	58	100	792	×	5	5	5			204-211	42.2-60.4	×
135	JM6-3 (F 1)	2019		Bread		irrigated	CN	56.4-57.7		25	43	85	788	×	5	5	5			197-207	40.0-43.1	×
136	Start	2015/2019		Bread		irrigated	RU	36.3-62.2		26	40	75	755	×	5	5	5			207-222	39.0-43.9	×
137	Xisorak	2016/2017/2018	2019	Bread		irrigated	UZ	40.0-62.6	3	30	41	80	729	×	5	4-5	4-5	90		202-215	39.9-53.1	×
138	Zimnitsa	2015/2016/2019/2020		Bread		irrigated	UZ	38.5-57.7	3	27	54	100	682	×	5	5	5			220-236	35.7-42.7	×
139	Mingchinor	2015/2017/2020		Durum		rainfed	UZ	13.6-21.5						×	3-5	4-5	4-5			144-198	32.8-34.6	×
140	Bunyodkor	2016/2020		Bread		irrigated	UZ	48.1-63.0		26	54	90	791	×	5	4-5	5			202-210	38.0-43.5	×
141	Drujba	2015/2016/2018/ 2019/2020		Bread		irrigated	UZ	46.2-59.0	3	33	40	85	797	×	5	5	5			214-221	39.8-41.1	×
142	Langar	2017/2020		Durum		rainfed	UZ	16.2-28.0		24	45	90	799	×	4-5	5	4-5			144-167	39.9-47.7	×
143	Sogdiana	2018/2020		Bread		rainfed	UZ	13.7-24.7		32	47	95	780	×	4-5	5	4.5			161-197	37.2-48.1	×
144	Yoqut-2014	2018/2020		Durum		rainfed	UZ	10.8-23.5		29	65	105	774	×	4-5	5	4.5			145-165	41.2-49.3	×
145	O'tkir	2019/2020		Bread		irrigated	UZ	37.1-61.0		25	38	90	719	×	5	5	5			226-238	40.0-43.0	×
146	Istiqlol 25	2019/2020		Durum		rainfed	UZ	53.4-72.9		31	27	85	754	×	4-5	3	4-5			203-211	40.8-51.2	×
147	G'allakor	2019/2020		Bread		rainfed	UZ	12.2-23.6		25	40	90	837	×	4-5	5	5			143-167	37.6-44.6	×
148	Alekseich	2019/2020		Bread		irrigated	RU	47.6-63.4		22	40	75	790	×	5	5	5			197-224	39.0-48.0	×
149	Bezostaya-100	2019/2020		Bread		irrigated	RU	41.3-58.5		30	38	85	811	×	5	5	5			195-224	34.6-42.8	×
150	Gurt	2019/2020		Bread		irrigated	RU	40.4-61.6		20	20	75	795	×	5	5	5			207-228	37.2-43.4	×

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151	Antonina	2019/2020		Bread		irrigated	RU	40.1-62.5		30	27	85	784	×	5	5	5			217-228	39.8-43.7	×
152	Sadaf	2008/2011/2012/2020		Durum		irrigated	UZ	50.5-56.1		30	44	85	824	×	5	4	4-5			201-205	39.0-42.0	×
153	Semru?	2017/2020		Bread		irrigated	UZ	49.4-71.6		16	51	90	802	×	5	4-5	4-5	90		208-240	40.0-42.0	×
154	Shams	2017/2020		Bread		irrigated	UZ	43.1-54.1		31	39	75	793	×	5	5	5	90		202-206	37.2-42.6	×
155	Aziz	2020		Bread		irrigated	UZ	56.3-57.0	3	26	37	95	734	×	5	3	4-5	90		205-218	31.3-42.4	×
156	Baraka	2020		Bread		irrigated	UZ	54.7-58.1	3	36	40	100	745	×	5	3	4-5	90		205-208	39.8-40.4	×
157	Sharof 100	2020		Bread		irrigated	UZ	42.6-57.4						×	3-5	2	4-5	80		204-223	38.4-42.4	×
158	Amira	2020		Bread		irrigated	UZ	47.0-60.0		29	45	85	805	×	5	5	4-5			202-216	35.2-41.0	×
159	Sanzar 40	2020		Bread		irrigated	UZ	45.5-61.2		28	30	90	788	×	5	5	5			203-218	36.2-47.0	×
160	Shukrona	2020		Bread		irrigated	UZ	42.6-67.3		29	44	95	735	×	5	5	5			203-215	39.0-43.9	×
161	Kesh-2016	2020		Bread		irrigated	UZ	49.9-65.6		24	27	90	785	×	4-5	4-5	5	90		204-212	35.0-40.8	×
162	Uzbekistan 25	2020		Bread		irrigated	UZ	43.0-62.5	3	36	40	100	731	×	4-5	4-5	5	90		209-240	35.8-43.0	×
163	Nasaf	2020		Durum		irrigated	UZ	48.6-68.9		28	52	90	786	×	5	5	4-5			204-220	41.0-42.5	×
164	Qadr	2020		Bread		irrigated	UZ	41.8-58.8						×	4-5	3-5	4-5	90		199-216	37.5-40.5	×
165	Nodir	2020		Bread		irrigated	UZ	45.0-55.2						×	4-5	3-5	4-5	90		196-208	37.2-42.9	×
166	Amangul	2020		Bread		irrigated	UZ	38.5-57	2	25	47	90	719	×	5	5	4-5	95		226-241	44.0-45.0	×
167	Chimboy	2020		Bread		irrigated	UZ	39		27	32	95	804	×	5	5	5			226	41	×
168	Ilgor	2020		Bread		irrigated	UZ	45.0-58.0		30	41	100	765	×	4-5	4-5	4-5			198-223	38.4-45.6	×
169	Janub gavhari	2020		Bread		irrigated	UZ	45.1		27	40	85	712	×	×	5	5	80		87-90	33.2	×
170	Navbahor	2020		Bread		irrigated	UZ	45.0-48.6		25	42	85	778	×	5	4-5	4-5			205-238	40.0-40.4	×
171	Kayraktash	2020		Bread		rainfed	UZ	21.1-24.0		32	66	95	817	×	×	4-5	4-5	90		144-147	32.0-44.6	×
172	Qizildon (Vatan)	2020		Bread		rainfed	UZ	13.4-27.0			42		803	×	4-5	4-5	4-5			140-165	39.2-47.2	×
173	Billurdon (Briliant)	2020		Bread		rainfed	UZ	14.6-27.0			48		798	×	4-5	4-5	5	80		147-164	42.0-49.8	×
174	Ravon	2020		Bread		rainfed	UZ	12.1-22.0		17	30	90	824	×	4-5	4-5	4-5			144-167	34.0-40.7	×
175	Bograt	2020		Bread		irrigated	RU	39.4-61.0		26	32	75	801	×	5	5	4.5			195-228	37.2-42.4	×
176	Velena	2020		Bread		irrigated	RU	55.7-62.4		28	30	90	751	×	5	5	5			211-228	36.0-42.1	×
177	Vexa	2020		Bread		irrigated	RU	50.0-53.7		28	44	80	817	×	5	5	5			209-224	35.4-41.2	×
178	Grekum-439	1983	2020	Bread		irrigated	UZ	18.4-20.6	4	26			704	14	5	4	5	90		145-175	33.5-34.9	70-85
179	Omad	2011/2012/2013	2020	Bread		irrigated	UZ	38.8-56.8		21		110		9.5	5	3	4	90		218-225	38.8-49.0	80-90
180	Moskvich	2007/2008/2009/2010	2020	Bread		irrigated	RU	33.0-54.8	2-4	28		100		12.3	5	3	4			208-219	35.0-42.1	80-90

Serial no.	Variety	Year registered	Year un-registered	Winter bread/durum wheat	spring bread/durum wheat	Irrigated/rainfed	Country code	Yield (t/ha)	Bread score	Gluten content (%)	Hardness (%)	Gluten deformation measurement	Test weight (g/l)	Protein content (%)	Cold tolerance (1-10)	Salt tolerance (1-10)	Lodging resistance (1-10)	Yellow rust tolerance	Brown rust tolerance	Days to maturity (days)	TKW (g)	Plant height, (cm)
181	Pamyat	2007/2008/2009/2010	2020	Bread		irrigated	RU	41.8-57.2	2-4	25		100		15.4	5	5	5			203-212	38.8-42.1	80-85
182	Shodlik	2009/2010/2011/2017	2020	Bread		irrigated	UZ	40.6-42.0	3	32	60	85	820	14.3	4-5	2	5	80		206-217	39.8-45.8	75-90
183	Elamon	2013/2015/2016	2020	Bread		irrigated	UZ	36.5-68.8	3	25	52	85	795	14.2	5	3	4	60		206-232	35.6-45.2	80-95
184	Hazrati Beshir	2013/2015	2020	Bread		irrigated	UZ	44		26	32	75	801	11.9	4-5	2	5	90		200-207	39.4-41.2	85-90

Annex 3. Number of wheat varieties received for DUS testing and protection (2017-2019)[22]

Wheat varieities	Year received	OrOriginator	Decision
Bread wheat			
Ilgor	2017	Research Institute of Experimental Biology and Genetics	Rejected
Ezoz	2017	Research Institute of Experimental Biology and Genetics	Rejected
Zarafshan	2017	Samarqand Agricultural University	Rejected
Barqaror	2017	Research Institute of Plant Industry	Rejected
Obod	2017	Research Institute of Plant Industry	Rejected
Nurafshon	2017	Research Institute of Plant Industry	rejected
Qizildon	2017	Research Institute of Cereals and Legume Crops*	Testing for patent
Sanzar 40	2017	Research Institute of Cereals and Legume Crops*	Testing for patent
Qipchoq suv	2017	Research Institute of Cereals and Legume Crops*	Testing for patent
No'shkent	2017	Research Institute of Cereals and Legume Crops*	2019 patented
Vatan	2017	Research Institute of Cereals and Legume Crops*	Testing for patent
Nodir	2018	Research Institute of Cereals and Legume Crops	Testing for patent
Sharof 100	2018	Research Institute of Cereals and Legume Crops	Testing for patent
Qadr	2018	Research Institute of Cereals and Legume Crops	Testing for patent
Umid	2018	Research Institute of Cereals and Legume Crops	Testing for patent
Alekseyich	2018	Krasnodar Research Institute	Testing for patent
Bagrat	2018	Krasnodar Research Institute	Testing for patent
Gurt	2018	Krasnodar Research Institute	Testing for patent
Stan	2018	Krasnodar Research Institute	Testing for patent
Velena	2018	Krasnodar Research Institute	Testing for patent
Adel	2018	Krasnodar Research Institute	Testing for patent
Bezostaya-100	2018	Krasnodar Research Institute	Testing for patent
Bexa	2018	Krasnodar Research Institute	Testing for patent
Antonina	2018	Krasnodar Research Institute	Testing for patent
Sarbon	2018	Research Institute of Cereals and Legume Crops**	Testing for patent
Yuksalish	2018	Research Institute of Cereals and Legume Crops**	Testing for patent
Andijon-3	2018	Research Institute of Cereals and Legume Crops	Testing for patent
Hamkor	2018	Research Institute of Cereals and Legume Crops	Testing for patent
Moskovskaya 39	2019	Krasnodar Research Institute	Testing for patent
Moskovskaya 40	2019	Krasnodar Research Institute	Testing for patent
Moskovskaya 56	2019	Krasnodar Research Institute	Testing for patent
Sarimustafa	2019	Turkey	Testing for patent
Durum wheat			
Nafis	2018	Research Institute of Cereals and Legume Crops**	Testing for patent
Odari	2019	Krasnodar Research Institute	Testing for patent

*Note: *Gallyaral Research Station; **Qashqadarya Branch*

[22] *Source: SVTC 2020 (personal communication)*

Annex 4: Seed production by varieties (2011-2019)[23]

Annex 4a: Irrigated wheat seed production

		2011			2012			2013			2014			2015			2016			2017			2018			2019	
Variety	Variety	Area (ha)	seed (ton)	Variety	Area (ha)	seed (ton)	Variety	Area (ha)	seed (ton)	Variety	Area (ha)	seed (ton)	Variety	Area (ha)	seed (ton)	Variety	Area (ha)	seed (ton)	Variety	Area (ha)	seed (ton)	Variety	Area (ha)	seed (ton)	Variety	Area (ha)	seed (ton)
Krasnodar -99	Krasnodar -99	286.1	71525	Krasnodar-99	359	89750	Krasnodar -99	393.5	98375	Krasnodar -99	399.5	99875	Krasnodar -99	401.5	100375	Krasnodar -99	311.5	77875	Krasnodar -99	270.2	67550	Krasnodar -99	227.2	56800	Krasnodar -99	106.2	26561.9
Tanya	Tanya	169.3	42325	Tanya	230.9	57725	Tanya	298.9	74725	Tanya	311.9	77975	Tanya	322.5	80625	Tanya	290.5	72625	Tanya	247.8	61950	Tanya	210.7	52675	Tanya	84.2	21041.3
Kroshka	Kroshka	231	57750	Kroshka	154	38500	Kroshka	66	16500	Kroshka	31	7750	Kroshka	23.5	5875							Kroshka	9.1	2275	Kroshka	15.7	3913.8
Polovchanka	Polovchanka	140	35000	Polovchanka	86	21500	Polovchanka	13	3250																		
Chillaki	Chillaki	89.7	22425	Chillaki	73.7	18425	Chillaki	62.7	15675	Chillaki	57.7	14425	Chillaki	53.7	13425	Chillaki	41.7	10425	Chillaki	31.7	7925	Chillaki	33.1	8275	Chillaki	39.7	9933.8
Moskvich	Moskvich	86.2	21550	Moskvich	105.2	26300	Moskvich	141.4	35350	Moskvich	151.4	37850	Moskvich	151.4	37850	Moskvich	151.4	37850	Moskvich	121.2	30300	Moskvich	35	8750			
Nikonya	Nikonya	31	7750	Nikonya	28	7000	Nikonya	10	2500	Nikonya	5	1250															
Kupava	Kupava	26	6500	Kupava	20	5000	Kupava	5	1250																		
Nota	Nota	14.1	3525	Nota	14.1	3525	Nota	38.1	9525	Nota	44.1	11025	Nota	39.1	9775	Nota	16.6	4150	Nota	16.6	4150						
Pamyat	Pamyat	9.5	2375	Pamyat	11	2750	Pamyat	19	4750	Pamyat	16	4000	Pamyat	13	3250	Pamyat	13	3250	Pamyat	12	3000						
Kuma	Kuma	5	1250	Kuma	5	1250	Kuma	18	4500	Kuma	18	4500	Kuma	18	4500	Kuma	18	4500	Kuma	16.5	4125						
Yesaul							Yesaul	27	6750	Yesaul	46	11500	Yesaul	46	11500	Yesaul	85	21250	Yesaul	69	17250	Yesaul	14.4	3600			
Vostorg										Vostorg	9	2250	Vostorg	9	2250	Vostorg	19.5	4875	Vostorg	19.5	4875						
Grom										Grom	3	750	Grom	7	1750	Grom	64	16000	Grom	94.5	23625	Grom	195.8	48950	Grom	165.9	41483.9
Gratsiya													Gratsiya	3	750	Gratsiya	24	6000	Gratsiya	52.2	13050	Gratsiya	47.1	11775	Gratsiya	18	4507.9
Yaksart																Yaksart	24	6000	Yaksart	53	13250	Yaksart	55.8	13950	Yaksart	46.2	11557.5
Andijon-4																Andijon-4	7.5	1875	Andijon-4	13.5	3375	Andijon	17.3	4325	Andijon-4	24.5	6132.8
Asr																Asr	7.5	1875	Asr	14.5	3625	Asr	19.8	4950	Asr	88.2	22054.6
Durdona																Durdona	6	1500	Durdona	9	2250				Durdona	11.1	2771.5
Bobir																Bobir	4.5	1125	Bobir	5.5	1375						
Dostlik																Dostlik	3	750	Dostlik	8	2000	Dostlik	9	2250	Dostlik	13.5	3381.3
Zimnitsa																			Zimnitsa	19.5	4875	Zimnitsa	6.6	1650	Zimnitsa	27.2	6798.6
Yuka																						Yuka	46.4	11600	Yuka	18.7	4665.5
Vassa																						Vassa	46.3	11575	Vassa	56.4	14107.8
Brigada																						Brigada	14.6	3650	Brigada	20.5	5118.2
Tabor																						Tabor	19.6	4900	Tabor	14.7	3676.5
Bobir																						Bobir	8	2000	Bobir	26	6511.7

[23] *Source: SVTC 2020 (personal communication)*

		2011			2012			2013			2014			2015			2016			2017			2018			2019	
Starshina																						Starsh-ina	8	2000	Starsh-ina	35	8750
Gozgon																						Gozgon	6.1	1525	Gozgon	59.6	14904.7
Zvezda																						Zvezda	5.8	1450	Zvezda	13.5	3380.9
Davr																									Davr	28.5	7135.6
Pervitsa																									Pervitsa	27.3	6815.3
Andijon-2																									Andijon-2	21.5	5369.9
Jayhun																									Jayhun	19.5	4878.5
Jasmina																									Jasmina	11.9	2972.8
Bunyodkor																									Bunyodkor	8.3	2076.2
Yesaul																									Yesaul	6.7	1687
Lebed																									Lebed	5.8	1451.8
Sila																									Sila	5.4	1358.3
Turkiston																									Turkiston	4.5	1125
Vostorg																									Vostorg	4.1	1022.8
Bezostaya-100																								Bezostaya -100	2.8	697.3	
Semurg																									Semurg	2.6	648.8
Alekseyich																									Alekseyich	2.4	587.9
Hisorak																									Hisorak	2.3	584.8
Antonina																									Antonina	1.9	467.7
Yog'du																									Yog'du	1.4	348.5
New varieties	New varieties	29.5	7375	New varieties	30.5	7625	New varieties	30.5	7625	New varieties	30.5	7625	New varieties	30.5	7625	New varieties	30.5	7625	New varieties	3.5	875	New varieties	57	14250	New varieties	46.8	11695.4
Total		**1117.4**	**279350**		**1086.9**	**271725**		**1123.1**	**280775**		**1092.6**	**273150**		**1118.2**	**279550**		**1118.2**	**279550**		**1077.7**	**269425**		**1092.7**	**3E+05**		**1088.5**	**272177.8**

Annex 4b:Rianfed wheat seed production

		2011			2012			2013			2014			2015			2016			2017			2018			2019	
Variety	Variety	Area (ha)	seed (ton)	Variety	Area (ha)	seed (ton)	Variety	Area (ha)	seed (ton)	Variety	Area (ha)	seed (ton)	Variety	Area (ha)	seed (ton)	Variety	Area (ha)	seed (ton)	Variety	Area (ha)	seed (ton)	Variety	Area (ha)	seed (ton)	Variety	Area (ha)	seed (ton)
Surkhak-5688	Surkhak-5688	44.7	5811	Surkhak-5688	41.7	5421	Surkhak-5688	41.7	5421	Surkhak-5688	41.7	5421	Surkhak-5688	41.7	5421	Surkhak-5688	14.4	1872	Surkhak -5688	5.6	728	Surkhak -5688	3.4	442	Surkhak -5688	5.6	728
Krasnovodapad -210	Krasnovodapad -210	20	2600	Krasnovodapad -210	19.5	2535	Krasnovodapad -210	19.5	2535	Krasnovodapad -210	19.5	2535	Krasnovodapad -210	19.5	2535	Krasnovodapad -210	19.5	2535									
Sanzar-6	Sanzar-6	13.5	1755	Sanzar-6	13.5	1755	Sanzar-6	13.5	1755	Sanzar-6	13.5	1755	Sanzar-6	13.5	1755	Sanzar-6	13.5	1755	Sanzar-6	16.4	2132	Sanzar-6	3.9	507	Sanzar-6	16.4	2132
Mars-1	Mars-1	9.5	1235	Mars-1	10	1300	Mars-1	10	1300	Mars-1	10	1300	Mars-1	10	1300	Mars-1	3.8	494									
Tezpishar	Tezpishar	9.1	1183	Tezpishar	12.1	1573	Tezpishar	12.1	1573	Tezpishar	12.1	1573	Tezpishar	12.1	1573	Tezpishar	12.1	1573	Tezpishar	21.3	2769	Tezpishar	6.9	897	Tezpishar	21.3	2769
Intensivnaya	Intensivnaya	5.3	689	Intensivnaya	5.3	689	Intensivnaya	5.3	689	Intensivnaya	5.3	689	Intensivnaya	3.8	494	Intensivnaya	3.5	455	Intensivnaya	4.9	637				Intensivnaya	4.9	637
Kokbuloq	Kokbuloq	3.5	455	Kokbuloq	3.5	455	Kokbuloq	3.5	455	Kokbuloq	3.5	455	Kokbuloq	3.5	455	Kokbuloq	30.7	3991									
Zamin																			Zamin	14.3	1859	Zamin	1.5	195	Zamin	14.3	1859
Hisorak																			Hisorak	9.2	1196	Hisorak	6.8	884	Hisorak	9.2	1196
Khazrati bashir	Other varieties	34	4420																Khazrati bashir	7	910	Hazrati bashir	7	910	Khazrati bashir	7	910
Other varieties	139.6	18148	Other varieties	34	4420	Other varieties	34	4420	Other varieties	34	4420	Other varieties	30.7	3991	Other varieties	62	8060	Other varieties	28.1	3653	Other varieties	11.3	1469	Other varieties	28.1	3653	
					139.6	18148		139.6	18148		139.6	18148		134.8	17524		159.5	20735		106.8	13884	40.8	5304			106.8	13884

Annex 5. Seed processing plants and storage facilities in Uzbekistan[24]

	Province	Location	Processing capacity (tons)	Storage capacity (tons)		Province	Location	Processing capacity (tons)	Storage capacity (tons)
1	Karakalpakstan	Nukus 1	10080	6300	35	Samarkand	Samarqand	7200	5600
2	Karakalpakstan	Nukus 2	2160	2100	36	Samarkand	Chelak	7200	5040
3	Karakalpakstan	Chimbay	180	252	37	Samarkand	Samarqand 2	3960	3500
4	Karakalpakstan	Takhiatash	1680	2002	38	Samarkand	Zirabuloq	9000	9660
5	Karakalpakstan	To'rtkol	3000	1960	39	Samarkand	Ishtikhon	9600	10920
6	Andijan	Pakhtabad	12000	7000	40	Samarkand	Jomboy	10800	10388
7	Andijan	Oltinko'l	48000	6160	41	Samarkand	Tayloq	7200	5600
8	Andijan	Izbozkan	24000	16800	42	Surkhondarya	Bandikhon	1200	1400
9	Andijan	Baliqchi	12000	8400	43	Surkhondarya	Jarqorgon	14400	13720
10	Andijan	Asaka	24000	23800	44	Surkhondarya	Qiziriq	3000	2240
11	Andijan	Qo'rg'ontepa 1	9000	6580	45	Surkhondarya	Termiz	14400	14140
12	Andijan	Qo'rg'ontepa 2	9600	7700	46	Surkhondarya	Muzrabod	14400	15400
13	Bukhara	Bukhara	13200	12544	47	Surkhondarya	Sherobod	14400	12264
14	Bukhara	Romitan	13200	10990	48	Surkhondarya	Sariosiyo	3600	2520
15	Jizzakh	Jizzakh	7200	5040	49	Surkhondarya	Sho'rchi	10800	10584
16	Jizzakh	Gallyaral	1800	1400	50	Sirdarya	Oqoltin	12000	8400
17	Jizzakh	Dostlik	9000	7560	51	Tashkent	Quyi chirchiq	12000	11200
18	Qashqadarya	Qarshi	10800	7840	52	Tashkent	Bo'ka	4800	3360
19	Qashqadarya	Koson	10800	10500	53	Tashkent	Chinoz	12000	10500
20	Qashqadarya	Muborak	3000	2100	54	Tashkent	Ohangaron	13200	11900
21	Qashqadarya	Kitob	9600	9380	55	Tashkent	Piskent	4500	2940
22	Qashqadarya	Yettitom	9600	9100	56	Tashkent	Gallaalter 1	3300	2100
23	Qashqadaryo	Shakhrisabz	14400	13720	57	Tashkent	Gallaalter 2	8460	6580
24	Qashqadarya	Shkarjuy	15000	11200	58	Fergana	Fargona	9000	8260
25	Qashqadarya	Nishon	15000	12180	59	Fergana	Margilon	6000	4480
26	Qashqadarya	Qamashi	3600	2100	60	Fergana	Bagdod	6000	7000
27	Qashqadarya	Yakkabog	6000	4900	61	Fergana	Quva	6000	6300
28	Navoi	Navoi	7200	7560	62	Fergana	Rapkon	9600	7700
29	Navoi	Navoi 2	14400	12460	63	Fergana	Qo'qon	10800	9240
30	Namangan	Toraqorgon	8400	6580	64	Khorazm	Khorazm	4800	3360
31	Namangan	Chortoq	14400	12460	65	Khorazm	Shovot	12000	10500
33	Namangan	Uchqo'rgon	14400	10920	66	Khorazm	Bogot	14400	11760
34	Samarkand	Nurobod	3960	2800	67	Khorazm	Khonqa	4800	4200
					Total	645,480	515,144		

[24] *Source: SVTC 2020 (personal communication)*

Annex 6. List of laws, regulations, resolutions, and decrees relevant to seed sector in chronological order

#	Laws, Presidential Decrees and Resolutions	Scope	Objectives	Date adopted and number	Remarks
Laws					
1	Law on "Certification of Products and Services"	General regulation on certification of products including seeds	Establishes legal and organizational foundation for certification of products, services and other objects, and rights, responsibility, and accountability of certification participants	December 28, 1993 #245	Certification Order PD-02-2003 for seed certification and is a standard document agreed with Uzdavstandart as part of national seed certification scheme
	Law on Standardization	General regulation on different products including seed quality standards	Procedures for certifying agricultural seeds, defines seed classes (except cotton seed); obligatory and complies with requirements of RST UZ 5.0 and RD UZ 51-62 standards and used by inspectorate and central seed testing laboratory, seed farms, seed processing plants, seed procurement centers, seed producers and consumers.	December 28, 1993	No amendments so far
	Civil code	Articles 456-457 are on Government procurement (contracting quotas) of agricultural products including seed.	Obliges farmers and research institutes to sell their produce (at lower price set by MoF) to "Agricultural Products Processing Enterprises" (all Government-controlled enterprises--joint stock companies, holding companies or agencies)	December 2, 1995 #163-I	
2	Basic Seed Law	Governs seed production and commercialization	Address seed production, maintenance of attributes of in variety renewal and replacement; effective use of national and international genetic resources, deriving and reproduction of new products	August 29, 1996 #267-I (August 29, 1996)	Amendments to Seed Law #252-I dated April 25, 1997, chapter XV of Seed Law #772-I dated April 15, 1999, # 521 dated February 16, 2019
	Law "On Breeding Achievements"	The Law is another seed related parliamentary level regulation.	Regulate IPR issues such as patenting procedure, testing for patenting, agencies responsible, breeder's rights and their protection	August 29, 2002 #395-II	Need amendments to the law
Presidential Decrees (PD)					
1	Measures to ensure healthy nutrition of Uzbekistan people (2015-2020)	Diversify cropping system and organize seed production of new crops in the country	The main objective of this decree is to ensure healthy nutrition of the population of Uzbekistan	August 29, 2015 PD #251	
	Measures to further reform and development of rural economy (2016-2020)	Improve seed production of new crops	Illustrates the Government's shift in policy toward diversification and intensification of agricultural crops, getting away from cotton monopoly and need for necessary infrastructure for development of new crops	December 29, 2015 PD #2460	
	Measures to support domestic exporters and enhance foreign economic activity	Removes farmers obligation to sell their products at fixed prices exclusively to public marketing enterprises; entitles farmers to export fruits, vegetables, grapes and lemons directly at market prices; formulate legislation and procedures in compliance with international plant quarantine standards and develop infrastructure (quarantine measures, laboratories, border measures); and implement reforms at legislative and institutional levels with participation of private sector in agricultural production and trade	Latest resolution and clearly demonstrates Government's shift in policy toward integration of agricultural sector of Uzbekistan to global economy	June 21, 2017 PD #258	

Political Economy of the Wheat Sector in Uzbekistan

In its effort to achieve national food security and food self-sufficiency, Uzbekistan has introduced several strategic and policy reforms since its independence from the former Soviet Union in 1991. One of the Uzbekistan Government's declared strategies was reducing dependency on food imports by increasing domestic winter wheat production. As a result, wheat area substantially increased from 0.6 million ha in 1992 to 1.3 million ha in 2019 – making wheat the most important crop, second only to cotton. Likewise, total production of wheat has exhibited an increase from 1.0 million tons in 1992 to 6 million tons in 2019. The notable increase in total production is mainly explained by the substantial average productivity gains from 1.66 tons ha^{-1} in 1992 to 4.65 tons ha^{-1} in 2019. The productivity gains are in turn partly explained by the high priority for irrigation given to wheat where 82% of total national wheat area is currently irrigated and partly by the wide adoption of improved wheat varieties and associated management practices. Past studies have documented that despite the satisfactory progress, a sizeable yield gap prevails and that it is possible to increase average yields in Uzbekistan to 7 tons ha^{-1} if Uzbek farmers strictly follow the recommended full packages of crop-management practices and have access to agricultural machinery.

Over the years, varietal release gained momentum where, 177 varieties out of the total of 184 were released after independence with most recently registered varieties coming from national breeding programs - showing progress in varietal portfolio. Though few in number (five varieties), the private sector has also started releasing varieties. In terms of distribution, most varieties were released from irrigated areas with only 22 for rainfed areas. The availability of such a large number of improved varieties has helped Uzbekistan to achieve high varietal replacement rate of 10.8 years where 72% of the farmers are cultivating wheat varieties with less than 10 years of age on 62% of total wheat area.

Seed production and marketing is centrally planned and executed by the Government. Data on wheat seed production and area coverage show that seeds of 43 varieties are on the market. The top five bread wheat varieties cover 44.6% of area which shows that unlike many countries where very few mega varieties dominate the wheat production landscape, varietal diversity in Uzbekistan is high. Apart from the small Dekhan farms, all large farms are believed to be cultivated with certified seed leading to high seed replacement rate. In the face of such a high varietal diversity and fast seed replacement rate, the relatively low national average yield levels, especially in the rainfed areas needs explanation. Understanding the adoption level of improved wheat varieties and associated management practices and identifying farm, farmer, and institutional factors that determine the country's ability to achieve large scale adoption and impacts of these technologies is also necessary.

This book, which is the first of its kind, not only attempted to compile all available (published and unpublished) data related to the wheat sector into one document but also provides a comprehensive description and analysis of the wheat sector in Uzbekistan from varietal development and release, to seed production, quality assurance, and marketing, to farmer varietal adoption, seed use and ultimately their impacts on livelihoods. More importantly, the book provides a synthesis of the whole sector, identifies lessons learned, draws conclusions, and makes some recommendations for the way forward. I believe this book will be an important source document for future studies on the wheat sector in Uzbekistan and for guiding policy and institutional changes that will enhance the sustainable development of the sector.

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