Chapter IV

Accelerated Seed Multiplication for Deployment of Rust-resistant Wheat Varieties

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4.1 Introduction

In Ethiopia, the number of public seed enterprises and private seed companies has increased recently and are being involved in wheat seed production. The public seed enterprises include Ethiopian Seed Enterprise (ESE), Bale Agricultural Development Enterprise (BADE), Oromia Seed Enterprise (OSE), Amhara Seed Enterprise (ASE), South Seed Enterprise (SSE) and Somali Seed and Forage Enterprise (SSFE). The private seed producers include Tinsae Agro PLC, Alemayehu Seed Producer PLC, Anno and Gadisa Seed Producer PLC., Ethio-vage and Z-Endeta private farms. Besides, several business-oriented seed cooperatives, for example, Edget Union, input marketing cooperatives are also engaged in wheat seed production through farmer groups mainly supported by development partners. The cooperatives are linked with both farmer groups and formal sector.

During the last four decades NARS has developed and released more than 67 bread and 33 durum high yielding and disease resistant wheat varieties (MoA, 2014). Since 1960's the national wheat average yield increased four-fold from 0.6 to 2.54 tons ha^{-1}. However, recurrent rust epidemics and short longevity of rust resistance of bread varieties posed

a major challenge to wheat production in the country. In recent years the emergence of new strain and variants of Ug99 and the yellow rust epidemics in 2010, posed a serious risk to millions of small-scale wheat producers. This chapter presents the approaches, achievements and lessons learned in accelerated seed multiplication of early generation seed (breeder, pre-basic and basic) and large-scale certified seed production by NARS and public and private sector including farmer seed producer groups during 2010/11-14/15 crop seasons as part of ICARDA-EIAR project.

4.2 Framework for Accelerated Seed Multiplication

Taking into account the framework described in earlier chapter, and using stakeholders' platforms at federal and regional levels, the accelerated seed multiplication component of the project implemented the following key activities:

- Identification and prioritization of rust affected target districts in each region aligned with AGP intervention areas;
- Identification of suitable wheat varieties for target districts;
- Estimation of potential seed demand and ensuring the availability of EGS;
- Ensuring accelerated seed multiplication through partnership involving NARS, public seed enterprises, private seed companies and farmer seed producers.

4.2.1 Identification and prioritization of target districts

The project aimed at addressing the agricultural growth program (AGP) districts as per government priority and donor interest where the stakeholders had identified and prioritized target districts based on severity of rust damage and potential wheat area coverage of each district (Table 4.1). In addition eleven non-AGP major wheat growing districts were included based on the recommendations of the regional bureaus of agriculture.

Table 4.1. AGP and non-AGP districts selected for scaling out seed technologies

Oromia		Amhara	SNNP	Tigray
Ada	Gololcha	Basoliben	Enemor Ener	Emba Alaje
Adaba	Guduru	Debre Eliyas	Endegagn	Endamehoni
Agarfa	Hitosa	Enemay	Mareko	Enderta
Aleltu	Horo	Guagusa Shikudad	Misrak Azernet	Hintalo Wajirat
Ambo	Limu-Bilbilo	Minjar	Shey Bench	Ofla
Bale	Lume	Moret	Soro	
Dendi	Munesa	Tarmaber		
Dodola	Shirka	Wenberima		
GedebAsasa	Sinana			
Gimbichu	Weliso			
Ginir	Ziquala			
Gololcha				
Total	**23**	**8**	**6**	**5**

4.2.2 Identification of suitable rust-resistant varieties for target districts

Deployment of yellow rust resistant wheat varieties were the primary focus and objective of the project. The project team from ICARDA and EIAR together with experts of the regional BoA selected available technologies including new and existing commercial wheat varieties with combined resistance to yellow and/or stem rust and associated agronomic practices suitable for each target district (Table 4.2).

Table4.2. List of rust-resistant wheat varieties distributed by the project and seed source

Variety	Source	Variety	Source
Digelu	ESE, ASE	Pavon-76	OSE
Danda'a	BADE, ESE, ASE	M/Welabu	Sinana RC
Kakaba	ASE, ESE, BADE	Bakalcha	Sinana
Tay	Adet, ASE	Illani	Sinana
Gasay	Adet, ASE	Tate	Sinana
Mekele-1	TARI	Toltu	Sinana
Mekele-2	TARI	Obsa	Sinana
Tuse	KARC	Ude	DZARC, Seed Asso
		Yerer	DZARC, Seed Asso

4.2.3 Ensuring availability of technologies

Once the technologies were identified, the project team and stakeholders had to ensure the availability of the required varieties. From the outset, an attempt was made to ensure that the available technologies were

sourced from federal and regional research centers, public seed enterprises (mainly Ethiopian Seed Enterprise) and Bale Agricultural Development Enterprise (BADE), and farmers' cooperatives. Accordingly, about 22 new and existing commercial wheat varieties with combined resistance to yellow and/or stem rust resistance (including *Kakaba* and *Danda'a*) were selected for rapid seed multiplication and dissemination.

4.3 Accelerated Seed Multiplication

To achieve its primary objective the project played a catalytic role in supporting early generation seed multiplication by NARS and linking that to large-scale certified seed production by the existing public seed enterprise and/or private seed companies as well as farmer seed producer's associations through the support of district BoA.

NARS made relentless effort mitigating the shortage of seeds through provisions of appropriate technological interventions. To avail enough amounts of early generation seeds (EGS) to seed producers, the following basic approaches of accelerated seed multiplication schemes were used as intervention:

- Pre-release seed multiplication: The project supported micro-increase and pre-release seed multiplication of promising lines and candidate varieties to accelerate variety release which otherwise be delayed due to shortage of sufficient seed to conduct national multi-location variety trials (see Chapter 3) and to get sufficient amount of basic seed upon variety release.
- Two crop cycles per year: Accelerated seed multiplication particularly of early generation was conducted both during the main season and off-season under irrigation by NARS (Kulumsa, Werer, Adet, Mekelle) and by seed enterprises (Koga and Upper-Awash);
- Using low seed rate to increase multiplication factor (MF): Lower seed rates and intensive crop management have been used for providing multiplicative advantage for rapid seed increase. For example an MF 250 was achieved on a small plot where a seed rate of 8 kg was used and a yield of 2 tons ha^{-1} was produced at Kulumsa ARC; and
- Strengthening capacity of seed producers: NARS were provided with facilities to strengthen the EGS production through provision of farm

machinery, irrigation, equipment for seed quality laboratory, seed packaging and seed storage.

4.3.1 Early generation seed multiplication

Availability of and access to EGS is critical for quick deployment of new crop varieties to farmers. However, past experience have shown that the small amount of source seed from NARS remain a major bottleneck for quick dissemination and adoption of new crop varieties.

Ten federal and regional agricultural research centers were involved in accelerated seed multiplication. The newly released varieties such as *Danda'a, Kakaba, Gambo, Shorima, Hoggana, Hulluka, Hidase* and *Ogolcho* among bread wheat varieties and *Werer* and *Mangudo* among durum wheat varieties from federal system *Mekelle 01, Mekelle 02,* and *Tay* were multiplied to replace the susceptible varieties. These activities considerably improved the EGS supply and provide formal and informal seed producers with sufficient seed for further multiplication and dissemination. Since 2010/11 about 7,587 MT EGS was multiplied by federal and regional research institutes and public seed enterprises (Table 4.3).

Table 4.3. Early generation seed multiplication of rust-resistant wheat varieties

Season	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	Total
Main season	667	3,419	367	1,015	974.7	500.5	6,943.2
Off-season	365	105	82.7	48.2	20.0	22.6	643.5
Total	1,032	3,524	449.7	1,063.2	994.7	523.1	7,586.7

Apart from NARS, EGS was multiplied by public and private seed producers where sufficient quantity of seed was supplied from the accelerated seed multiplication scheme organized by the project. Different classes of EGS were provided to public seed enterprises and small-scale seed companies and farmer's seed producers associations. About 1553.4 tons of pre-basic and 22,215.4 tons of basic seed was produced by public seed enterprises at federal (ESE) and regional (OSE) levels (Tables 4.4, 4.5 and 4.6). A considerable effort in EGS multiplication by NARS and public seed enterprises with the express purpose of replacing rust susceptible varieties made significant contribution in dissemination of new resistant varieties.

Table 4.4 Early generation seed multiplication of rust-resistant wheat varieties by NARS from 2010/11 to 2015/16

Year	Season	Bread wheat			Durum wheat			Total
		New	Existing	sub-total	New	Existing	Subtotal	
2010/11	Main season	668.3	0	668.3	*0*	0	0	668.31
	Off-season	379.6	0	379.6	*0*	0	0	379.6
2011/12	Main season	3263.8	305.9	3569.7	*1.36*	25.04	26.4	3596.12
	Off-season	379.6	0	379.6	*0*	0	0	379.6
2012/13	Main season	224.3	113	337.3	*4.7*	24.9	29.6	366.9
	Off-season	181.4	23.2	204.6	*0*	0	0	204.6
2013/14	Main season	469.62	144.18	613.8	*15.62*	15.07	30.69	644.493
	Off-season	29.8	0	29.8	*4.2*	9.55	13.75	43.554
2014/15	Main season	418.29	224.33	642.62	*62.33*	166.09	228.42	871.04
	Off-season	20	0	20	*0*	0	0	20
Total	Main season	4376.01	787.41	5163.42	*84.01*	231.1	315.11	5478.53
	Off-season	610.8	23.2	634	*4.2*	9.55	13.75	647.75

[1]Seed produced by KARC, ESE, ASE, OSE, BADE and Tinsae PLC; [2] Koga irrigation (ESE+ASE) included; [3] KARC, HARC, DZARC, SARC, MARC, SIARC, AARC; [4] Werer and Mekelle

Table 4.5 Pre-basic seed multiplication by public seed enterprises

Variety	2010/11			2011/12		2012/13		2013/14	2014/15	Total
	ESE	OSE	ASE	ESE	OSE	ESE	OSE	ESE	OSE	
Kakaba	-	150	150	1,254	15	893	120	476	762	3,820
Danda'a				764	13	728	120	322	338	2,285
Hulluka				4	40	78		66	134	322
Shorima	764			4		74		54	41	936
Hidase					75	29		131	700	935
Hoggana					15	13		44	72	144
Ogolcho					75	20		54	67	216
Digalu	1,254			202	53	332	100	53	35	2,029
Pavon-76				334		172		-	-	506
Hawi	334			305		70		-	-	709
Mekele-1	4									4
Mekele-2	4									4
Madda Walabu	202					-		-	-	202
Simba	305			120		15			-	440
Kubsa	328			2,007		-		-	-	2,335
Galema	120			328		-		-	-	448
Ude	7			7		7		-	-	21
Total	15,354	150	150	5,329	285	2,431	340	1,199	2,149	15,354

Table 4.6. Basic seed multiplication by public seed enterprises

Variety	2010/11	2011/12		2012/13			2013/14			2014/15		Total
	ESE	ESE	OSE	ESE	OSE	SSE	ESE	OSE	SSE	ESE	OSE	
Kakaba		1,458		16,506	245	2,297	23,380		3,245	23,380	3,784	74,295
Danda'a				3,702	968	1,062	2,776	2,430	1,500	2,776	2,012	17,225
Hulluka					20		232			232	1,003	1,487
Shorima					80		583			583	2,027	3,273
Hidase							665			665	4,638	5,968
Hoggana							72			72	131	275
Ogolcho							238	60		238	5,282	5,818
Digalu	1,458	1,676		2,909	1,865	3,101	1,053	1,519	5,112	1,053	237	19,982
Pavon	287	4,713		1,629	450	68			78		1,757	8,981
Hawi	4,713	2,447		15,510	26							22,696
Simba	2,447	1,973				511			722			5,653
Kubsa	2,630	46,410		1,092	304							50,437
Galema	1,973	2,630		1,381	81							6,065
Total	13,509	61,308	-	42,728	4,038	7,039	28,998	4,008	10,656	28,998	20,871	222,154

4.3.2 Large-scale certified seed production

Currently, the public seed enterprises (PSEs) are the major players in the formal wheat seed supply while the role of private seed enterprises is still remain insignificant. The PSEs and seed producers associations were provided with large quantities of EGS of new/old rust-resistant wheat varieties for further multiplication and distribution. The project made strategic partnership with federal and regional PSEs and farmer seed producers associations to produce and market certified seed on a larger scale across the country. The project linked its activities to the Ethiopian Seed Enterprises (ESE), Amhara Seed Enterprise (ASE), Oromia Seed Enterprise (OSE), South Seed Enterprise (SSE), private seed producers, farmers unions and seed associations that are involved in seed production.

The linkage of PSEs with farmer-based seed multiplication schemes promoted by the project provided wider option for procuring and distributing seed through contractual agreement with farmers or associations.

a) Partnering with farmer's seed producers associations

To alleviate the seed shortage the project worked with semi-informal farmers' seed producers associations. The associations, usually established with about 25 members, were encouraged to gradually transform to formal seed producers depending on their capability. The associations were assisted through the provision of basic seed of rust-resistant improved varieties and technical backstopping. These associations include Biftu, Chala, Giche Garababo, Hundaf Hatau, Megertu Denkaka, Memhir Ager, Ude and Utuba Jirena. A total of 61.7 tons of source seed of rust-resistant wheat varieties among them Kakaba were provided during the project where it was further multiplied and distributed through formal and informal channels (Table 4.7). The associations serve as source of seed for farmers at local level and PSEs.

Table 4.7. Amount of wheat seed provided and seed produced by farmer seed producers associations

	2012/13	2013/14	2014/15	Total
Seed supplied (t)	9.7	15.7	36.3	61.7
Area planted (ha)	64.7	104.7	242	411.4
Seed produced (t)	226.5	366.3	847	1439.8
Area covered (ha)	1510	2442.2	5647	9599.2

b) Partnering with public and private seed companies

Rapid replacement of millions of ha of wheat with rust-resistant varieties requires multiple partners for massive seed production. The federal and regional public seed enterprises played a key role in this endeavor where seed of new and existing commercial rust-resistant varieties from federal and regional NARS were multiplied on their own farms or on clustered farmers' fields to produce sufficient quantity and quality seed for large-scale distribution to farmers (Table 4.8).

The project builds on successive wheat projects where ICARDA supported fast track testing and accelerated seed multiplication within the BGRI (ex GRI) initiative first to tackle Ug99 and subsequently the deployment of yellow rust resistant varieties. The availability of new wheat varieties such as *Danda'a* and *Kakaba* with combined resistance to Ug99 and yellow rust helped in rapid multiplication both of EGS and certified seed. During the four years of the project 226,135 tons of rust-resistant varieties were multiplied and, capturing a significant proportion of certified seed supply together with existing commercial varieties.

Table 4.8. Certified seed production of rust-resistant wheat varieties

Variety	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	Total
Newly released bread wheat varieties (≥2010)							
Kakaba	205	3,370	14,654	14,967	28,515	23,692	85,404
Danda'a	553	2,252	12,363	7,344	13,428	14,150	50,090
Shorima	0	-	24	10	22	99	155
Hulluka	0	-	2	254	268	268	792
Ogolcho	0	-	-	14	44	647	705
Hoggana	0	-	-	2		2	4
Hidase	0	-	-	8	28	1,188	1,224
Gambo	0	-	-	-		-	-
Tsehay	0	-	-	-		-	-
Mekelle 1	0	22	17	3	2	1	45

Mekelle 2	0	86	10	-	0	-	96
Jeferson	0	-	292	-	-	-	292
Global	0	-	22	-	-	-	22
Sub-total	758	5,730	27,384	22,602	42,307	40,047	138,829
Existing commercial bread wheat varieties (<2010)							
Hawi	456	1,860	3,422	3	98	13	5,852
Tuse	986	1,214	832	421	68	-	3,521
Mada Walabu	164	20	900	515		28	1,627
Simba	604	2,191	1,084	-	271	158	4,308
Shina		134	61	1,100	15	-	1,310
Sofumar		195	183	-	225	110	713
Digalu	3833	9,173	11,740	4,306	9,426	5,657	44,134
Meraro		-	-	-	-	-	-
Millenium	144	-	-	-	-	-	144
Pavon-76	5011	4,416	7,034	2,124	2,539	3,997	25,120
ET 13	0	58	-	-	-	-	58
Menze	0	-	85	-	20	-	105
Enseno-1	0	-	51	-	-	50	101
Tay	0	-	-	-		27	27
Sub-total	11197	19,260	25,392	8,469	12,662	10,040	87,020
Durum wheat varieties							
Buhe	4.6						
Kilinto	0.6						
Mangudo	0	-	-	-		16.0	16.0
Tate	0	-	50.0	-	-	-	50.0
Ude		-	6.0	7.0	102.0	73.0	188.0
Yerer		-	27.0	-	-	-	27.0
Sub-total	5	-	83.0	7.0	102.0	89.0	286.2
All certified seed (resistant)	11,960	24,990	52,859	31,078	55,071	50,176	226,135
All certified seed (wheat)	27,086	38,736	71,078	59,810	70,738	60,430	327,878

4.4 Achievements of the Project

During the last couple of years, there is a continuous and substantial increase in certified seed demand and supply. In recent years, there is massive scaling out activities by the government programs and different projects where awareness and demand for new varieties and seeds increased dramatically.

When we compare the certified seed of wheat produced by the formal sector, the amount doubled from around 27,000 tons in 201/11 to over 60,000 tons in 2015/16 season. Since 2009, the projects to accelerate seed multiplication of resistant varieties funded by USAID, EAAPP, etc have greatly contributed to the replacement of the widely grown and highly susceptible varieties such as *Kubsa* and *Galema*. The two bread wheat varieties covered about 57% of the wheat seed supply (Figure 4.1). After project intervention the susceptible varieties were replaced by the newly rust-resistant varieties (Figure 4.2). In 2015/16, the wheat seed production was mainly dominated by the newly released and rust-resistant varieties such as *Kakaba* (40%) followed by *Danda'a* (24%) from a total of 60,430 tons. The amount of rust-resistant wheat seed of lately released varieties like *Hidase, Ogolcho, Hulluka* and *Shorima* is increasing and replacing *Digalu*, which is now susceptible to stem rust. This is one of the fastest turnaround in terms of deploying rust-resistant varieties.

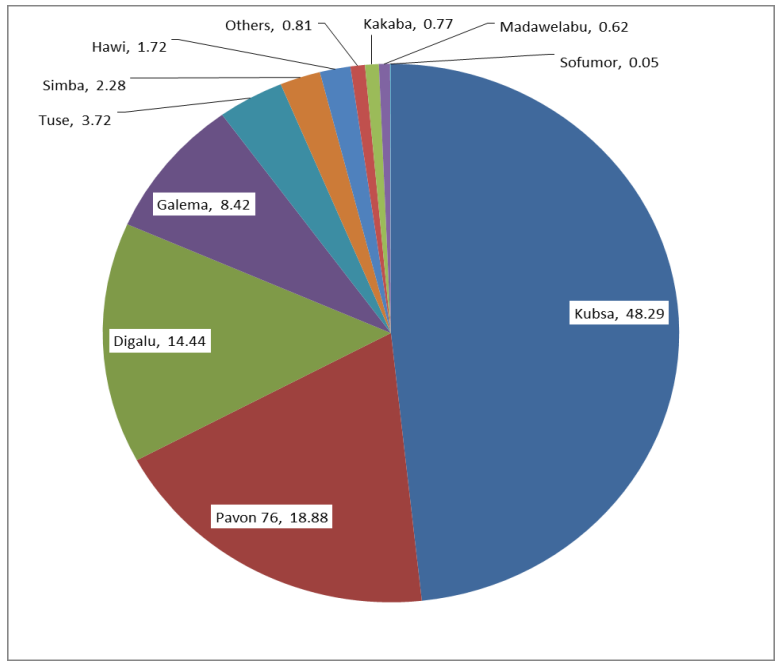

Figure 4.1 Varietal composition of certified seed production in 2010/11 crop season

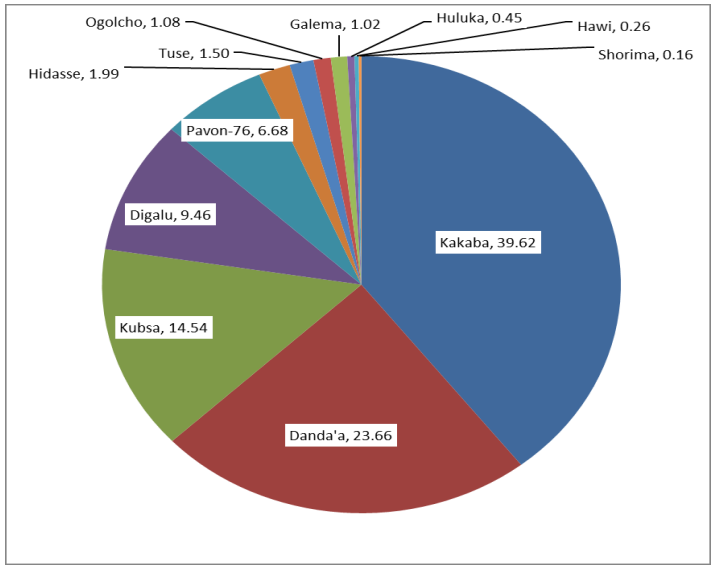

Figure 4.1 Varietal composition of certified seed production in 2015/16 crop season

During the project period the price of certified seed increased from 565 ETB in 2010/11 to 1008 ETB in 2012/13 and to 1,450 ETB in 2016/17 crop seasons, an increase of three fold. However, despite continuous price rise there is an increasing demand for certified seed showing farmers appreciation for quality seed.

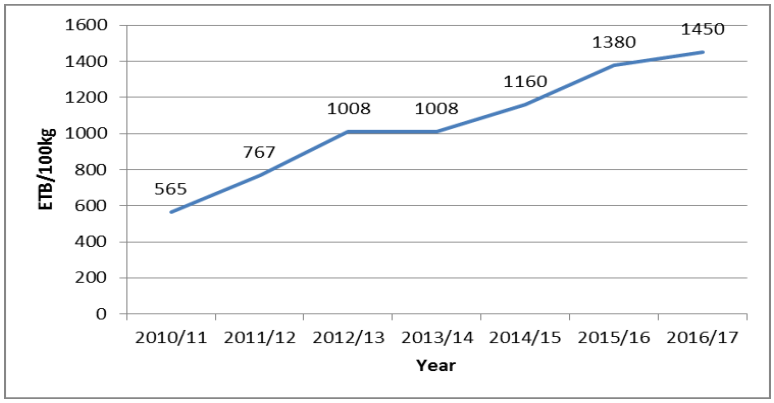

Figure 4.3. Wheat certified seed price (ETB) during 2010-16

4.5 Conclusion and Lessons Learned

The project was very successful in supporting and strengthening the accelerated seed multiplication for replacement of susceptible wheat varieties in the shortest possible period of time (about three to four years). However, most of the released yellow rust resistant varieties are now become susceptible to new strain of stem rust (Digalu race). Therefore continuous effort would be required in developing and releasing durable rust-resistant varieties by the NARS. In addition, most of the newly released varieties are not quickly multiplied by formal seed producers as expected. There is a need to create awareness about wheat rust with the public and private sector and farmers' groups and popularization of resistant varieties. In order to enhance the capacity of NARS, there is a need for continued collaboration with ICARDA and CIMMYT and other international wheat research centers; and donor assistance to deepen the achievements and mitigate emerging stem rust threat through capacity development.

The following are some of the lessons learned during project implementation period:

- The project demonstrated effective interventions with long-term impact to ensure sustainability. The project investment was enabled sustainable source (basic) seed supply by NARS.
- There is need to design long-term strategy on mitigating wheat rusts as evident from the recent outbreak of new strain of stem rust through diversification of cropping systems by incorporating legumes mainly chickpea and rape seed to break wheat mono-cropping in the highlands and promoting durum wheat (less rust pressure) along with bread wheat production;
- The need for linkages with seed sector actors and the need to promote decentralized seed production to reach different agro-ecologies and farmers;
- Considerations for expanding irrigated wheat for both bread and durum to boost production; and
- Strong and effective partnership among NARS and seed sector stakeholders and IARCs (ICARDA) and strong donor support (USAID)