Success in seed multiplication and delivery efforts at UAS, Dharwad

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Introduction

Seed is a basic, vital and central input in agriculture and in all farming systems. Timely availability of quality seeds of varieties/hybrids adapted to to different agro-climatic conditions and in sufficient quantity at affordable prices is a measure of the strength and health of an agricultural economy. Sustained increase in agricultural production requires a continuous development of improved crop varieties/hybrids, an efficient system of production, and a means of distribution to farmers.

India is one of the few countries where the seed sector has advanced in parallel with the agricultural production. However, the availability of quality seed of improved varieties and hybrids is grossly inadequate and is a major constraint to enhanced production. Studies made by several workers (Gadwal 2003, Patil et al 2004, Hanchinal et al. 2007) clearly indicate that with high-volume low-value seeds, such as wheat, groundnut, soybean and chickpea, 80% of the cropping area is sown with farm-saved seeds of old and obsolete varieties

During last few decades, a number of high yielding disease and pest resistant varieties/hybrids in different crops had 10 to 40% yield superiority over local cultivars. With the exception of high-value low-volume seeds, seed production of low-value high-volume crops is generally left to public sector agencies. The bulky nature of most self pollinated crops, and lack of adequate investment on infrastructure means low remuneration. Although there is enough breeder seed production in most of the high volume crops, further seed multiplication through the foundation and certified seed stages are major constraints to the availability of quality seed. The present rate of seed replacement (SRR) for such crops is 6 to 8%. There is a need to increase SRR to 25 to 30% in varieties and obviously 100% for hybrids.

To increase the productivity of low-value high-volume crops farmers need to have access to improved seeds of the right type, at the right time, at the right place and at a reasonable price. For supply of such seeds, both the informal seed sector (farmer managed seed systems) and the formal seed system (seed enterprises) need to be engaged. The informal seed sector is often highly effective in reaching isolated, inaccessible, small holder areas and is a sound opportunity for entrepreneurs to gradually evolve into the formal enterprises

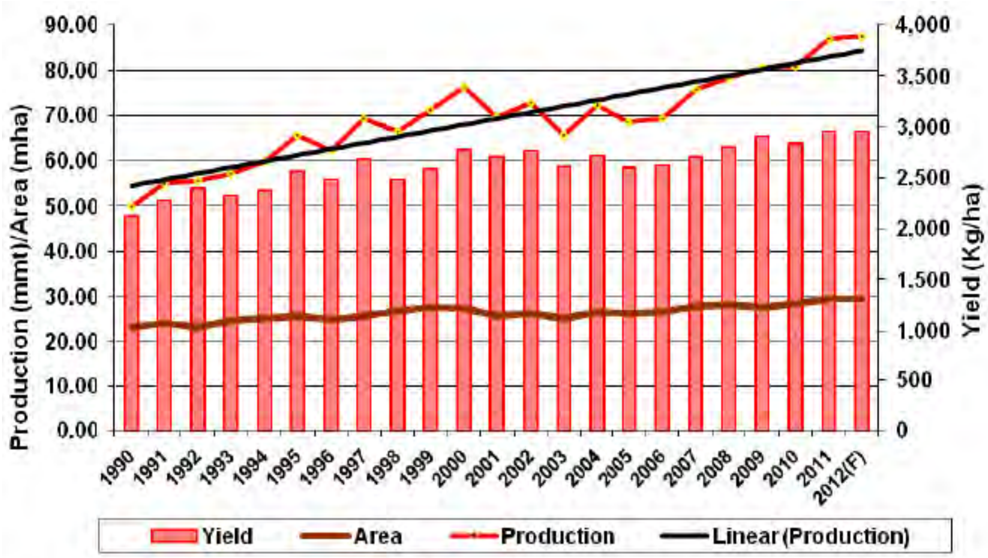
Wheat, the most important food crop of world and backbone of global food security, belongs to the high-volume low-value seed group. Of the total area sown to both hexaploid bread wheat and tetraploid durum and emmer wheat worldwide, 44% (95 m ha) is in Asia. Of this,62 m ha are located in just three countries viz. China, India, and Pakistan (Table 1 and Figure 1). Food security and production stability are of paramount importance in most Asian countries, given that the majority of farmers are poor. The wheat rusts have historically been major biotic constraints both in Asia and the rest of the world. Stem rust has been under control since the beginning of the green revolution in South and West Asia in the 1960s. Leaf rust and stripe rust continue to be major threats to production over approximately 60 (63%) and 43 (46%) m ha, respectively, in Asia. Although, the timely application of fungicides can provide adequate control, their use adds to production costs and they are considered environmentally unsafe. Growing resistant cultivars is thus the most effective and efficient control strategy, as it has no cost to farmers and is environmentally safe. Rapid evolution of races with new virulences, or combinations of virulences, dictate a need for discovery and deployment of new resistance genes and/or resistance gene combinations.

 ISBN: 13: 978-0-615-70429-6

Table 1. Wheat statistics for India

Year	Area (m ha)	Production (m t)	Productivity (t/ha)
2001-02	26.3	72.8	2.8
2002-03	25.2	65.8	2.6
2003-04	26.6	72.1	2.7
2004-05	26.4	68.6	2.6
2005-06	26.7	69.4	2.6
2006-07	28.5	74.9	2.6
2007-08	28.1	78.6	2.8
2008-09	27.8	80.68	2.9
2009-10	28.5	80.70	2.8
2010-11	29.3	85.93	2.9
2011-12*	29.4	90.3	3.0

** IV advance estimate, Ministry of Agriculture, New Delhi*



Source: Ministry of Agriculture, GOI; and FAS/New Delhi estimates for MY 2012/13

Figure 1. Area, production and yield for wheat, India 1990-2012

Wheat has two properties that render rapid impact of new varieties (Tables 2 and 3): high seeding rates (100 kg/ha or higher), and a very low seed multiplication ratio. One hundred kilograms of seed planted on a hectare of land will usually produce between 3,000 and 6,000 kg of grain, that is, corresponding multiplication ratios of 30 and 60. The magnitude of the challenge of wheat seed systems is further complicated by the small size of farms and correspondingly enormous numbers of customers. Predominance of small-scale farms (1-2 ha) also renders the task of seed production more challenging, because of the number of farmers that need to be involved in producing seed.

Table 2. Seed replacement rates in major Asian countries

Country	Crops	Seed Replacement Rate (%)
India	Wheat	25.0
	Rice	30.1
	Maize	48.5
Pakistan	Wheat	22.0
	Rice	37.0
	Maize	26.0
Bangladesh	Wheat	57.8
	Rice	47.4
	Maize	91.6
Nepal	Wheat	8.3
	Rice	6.6
	Maize	5.9

Table 3. Bridging the yield gaps

			Improved technology and variety			Existing varieties		
State	Area	State yield (t/ha)	FLD yield (t/ha)	Gap (t/ha)	Additional Production (m tons)	FLD yield (t/ha)	Gap (t/ha)	Additional Production (m tons)
Uttar Pradesh	9.67	2.88	4.27	1.39	**13.4**	3.88	1.00	**9.7**
Punjab	3.54	4.31	4.75	0.44	**1.6**	4.39	0.08	**0.3**
Haryana	2.49	4.21	4.93	0.72	**1.8**	4.76	0.55	**1.4**
Rajasthan	2.39	2.85	4.25	1.40	**3.3**	3.65	0.80	**1.9**
Madhya Pradesh	4.28	1.84	3.56	1.72	**7.4**	2.74	0.90	**3.9**
Bihar	2.23	2.08	4.04	1.96	**4.4**	3.55	1.47	**3.3**
Gujarat	0.91	2.90	3.89	0.99	**0.9**	3.53	0.63	**0.6**
Maharashtra	1.08	1.63	2.79	1.16	**1.3**	2.44	0.81	**0.9**
WB	0.3	2.31	2.79	0.48	**0.1**	2.32	0.01	**0.0**
All India	28.52				**34.2**			**21.8**

The path from plant breeding to variety uptake and utilization is a continuum of activities. New wheat varieties not only need to be rust resistant but also must have the agronomic, organoleptic and market characteristics that farmers and consumers require. Most public plant breeding programs produce just enough seed of the varieties being considered for release to supply a modest testing program. In normal circumstances, this is an understandable conservation of resources, but under the threat of rust and in view of ever increasing food security concerns, it is necessary to have more seed of pre-released varieties available for extensive testing and to get a head start on the seed multiplication process. This may imply the need for additional resources at an early stage. Most countries require that varieties pass independent agronomic performance tests and be examined in a DUS (distinctness, uniformity, stability) test to ensure that a candidate for release is novel.

The diversity of resistance in the Indian subcontinent can be maintained by growing cultivars that carry different resistance genes (Table 4). However, there is a general tendency for farmers to grow only one or a few favored cultivars, which, as a result, come to occupy large areas. Examples of this are varieties 'PBW343' and 'Inqualab 91' grown on 7 and 6 m ha in India and Pakistan, respectively. These cultivars are also grown in other countries under different names. Unfortunately, both cultivars carry stripe rust resistance gene *Yr27*, for which virulence has become widespread on the Indian subcontinent. Growing few cultivars that carry race-specific resistance genes leads to greater genetic uniformity and consequently greater vulnerability to disease and other threats.

Table 4. Preferred varieties in India

Wheat type	Production type			
	Normal sown	Late sown	Rainfed	Sodic soils / Others
North Western Plains Zone (NWPZ) Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions), Western UP (except Jhansi division), parts of J&K (Jammu and Kathua districts), HP (Una dist. and Paonta valley) and Uttarakhand (Tarai region)				
Bread wheat	DBW 17, PBW 550, PBW 502, PBW 343, WH 542, UP 2338, HD 2687, HD2967	WH 1021, PBW 373, UP 2425, RAJ 3077, DBW 16, RAJ 3765, PBW 590	PBW 299, PBW 175, WH 533, PBW 396	RAJ 3077, KRL-19, KRL 210, KRL 213
Durum	PBW 34, PDW 215, PDW 233, WH 896, PDW 291, PDW 314	-	-	-
North Eastern Plains Zone (NEPZ) Eastern UP, Bihar, Jharkhand, Orissa, West Bengal, Assam and plains of NE States				
Bread wheat	CBW 38, Raj 4120, K 0307, NW 1012, HUW 468, PBW 443, HD 2733, HD 2824, K 9107, HD 2967, DBW 39	HD 2643, HP 1633, HP 1744, NW 1014, HW 2045, DBW 14, NW 2036, HD 2985	HDR77,K8962,K 9465, K 8027, HD 2888, MACS 6145	RAJ 3077, KRL-19 KRL 210, KRL 213
Central Zone (CZ) MP, Chhattisgarh, Gujarat, Rajasthan(Kota and Udaipur divisions) and UP(Jhansi division)				
Bread wheat	GW 190, GW 273, DL 803-3, GW 322, GW 366, HI 1544	GW 173, DL 788-2, MP 4010, HD 2932, MP 1203, HD 2864	HW 2004, JWS 17, HI 1500, HI 1531, Sujata	RAJ 3077, KRL-19, KRL 210, KRL 213
Durum	HI 8381, HI 8498, MPO 1215	-	HD 4672, HI 8627	-
Peninsular Zone (PZ) Maharashtra, Karnataka, Andhra Pradesh, Goa, Plains of Tamil Nadu				
Bread wheat	DWR 162, MACS 2496, GW 322, Raj 4037, NIAW 917, UAS 304, MACS 6222, MACS 6273	DWR 195, HD 2501, NIAW 34, HUW 510, HD 2932, HI 977, HD 2833, PBW 533, Raj 4083, AKAW 4627	K 9644,HD 2781, PBW 596, HD 2987	_
Durum	MACS 2846, HI 8663, UAS 415, UAS 428	-	AKDW 2997-16	-
Emmer	DDK 1025, DDK 1029, DDK 1066	-	-	-

Indian assert

Although scientists that the climatic

 ISBN: 13: 978-0-615-70429-6

conditions in the major wheat belt of north India are not conducive to the spread of stem rust, including that caused by *Pgt* race Ug99, there must be a realistic consideration of the possibility that this race and its derivatives have different fitness attributes, especially given that most of the wheat varieties planted in India are highly susceptible to Ug99. ICAR and the state agricultural universities (SAUs) continuously survey and monitor the wheat crop for various rusts, including race Ug99. ICAR also screens newly released wheat varieties and advanced lines within the country and in Kenya. Because of the susceptibility of most of the local varieties, such as PBW 343, PBW 502 and HD 2687, to race Ug99, the government has been encouraging their replacement with Ug99-resistant varieties such as DBW 17, PBW 550, and HW 542.

Wheat breeding strategies for a number of years has involved the stacking or pyramiding of pathotype-specific genes. While gene stacking could be considered a short-term remedy, long-term breeding solutions through the use of durable host resistance must be strongly advocated. In order to quickly replace susceptible wheat varieties with new resistant varieties, countries will need support to enhance the effectiveness of their national systems for varietal registration and release, through which all potentially resistant varieties must pass before they can be released for distribution.

As it is well known that the seed replacement rate has a strong positive correlation with crop productivity, there is a need to enhance the seed sector through public sector seed companies, including the state seed corporations and other viable seed supply systems. It has been proved beyond doubt that the quality seed of improved varieties can alone increase the crop yields by 15-20% (Gadwal, 2003). It has been demonstrated that use of quality seed in wheat results in higher productivity (54.7 q/ha) as compared to use of farmer saved seeds (48.9 q/ha) because of higher genetic purity (99.7%) in quality seeds as against farm saved seeds (96.9%) (Gupta, 2012). It is also well recognized that the production of quality seed meeting the prescribed standards of genetic and physical purity, seed health, vigor, viability and storability is a specialized and scientifically based activity requiring detailed attention.

Production of an adequate quantity of breeder seed is a major responsibility of the National Agricultural Research System to meet the demands of the seed industry for production of foundation and certified seeds. In India, this responsibility is borne by ICAR at its research institutions along with the SAUs. To cope up with the increasing demands for breeder seed, the ICAR created Breeder Seed Production Units in almost all SAUs and crop-based ICAR institutes in 1979-80. Realizing the importance of quality seed in agricultural production the University of Agricultural Sciences, Dharwad, started a separate independent Seed Unit in 1996 with a Special Officer (Seeds) as administrative head and involving research stations The unit is responsible for seed production of a range of crops, and is also encouraged to undertake research activities related to seed production and technology, including post-harvest technologies. (Table 5)

Table 5. Breeder seed production of wheat by UAS, Dharwad

Variety	Quantity produced				
	2006-07	2007-08	2008-09	2009-10	2010-11
DWR 162	85	200	160	100	128
DWR 1006	0	0	12	5	11
DWR 39	10	16	22	5	0
DWR 195	10	19	5	2	12
DWR 185	120	10	15	10	0
DWR 2006	0	10	5	10	0
DDK 1001	2	2	2	5	0
DDK 1009	30	8	0	5	0
DDK 1025	0	40	50	5	20
DDK 1029	0	0	20	5	28
LOK 1	600	200	369	300	80
HD 2189	450	400	333	200	192
DWR 225	0	0	60	10	0
B. Yellow	5	5	1	5	0
Kiran	5	5	1	5	0
GW 322	0	0	0	0	293
UAS 415	0	0	0	0	55
UAS 304	0	0	0	0	60
MACS 6222	0	0	0	0	29
Total	1317	915	1055	672	908

Mandates of the Seed Unit at UAS, Dharwad

As summarized by activities described below, the mandates of the UAS Seed Unit are:

- To produce adequate quantities of nucleus, breeder, foundation and certified/TL seeds of high quality as per national and state requirements
- To maintain the genetic purity of crops varieties/parental lines of hybrids and planting material
- To generate basic information on seed certification standards including seed health
- To make linkages with crop improvement projects, seed industry, seed certification agencies, NGOs, KVKs (Krishi Vigynana Kendras/Farmer Science Centers) and farmers
- To establish public-private, national and international linkages for strengthening seed production and seed research
- To augment the seed research/production program to make it relevant to the needs of the farming community
- To disseminate information through training on seed production, processing, storage and packaging, quality control and seed health and by conducting demonstrations and field day

The activities of the seed unit are summarized in Figure 2.

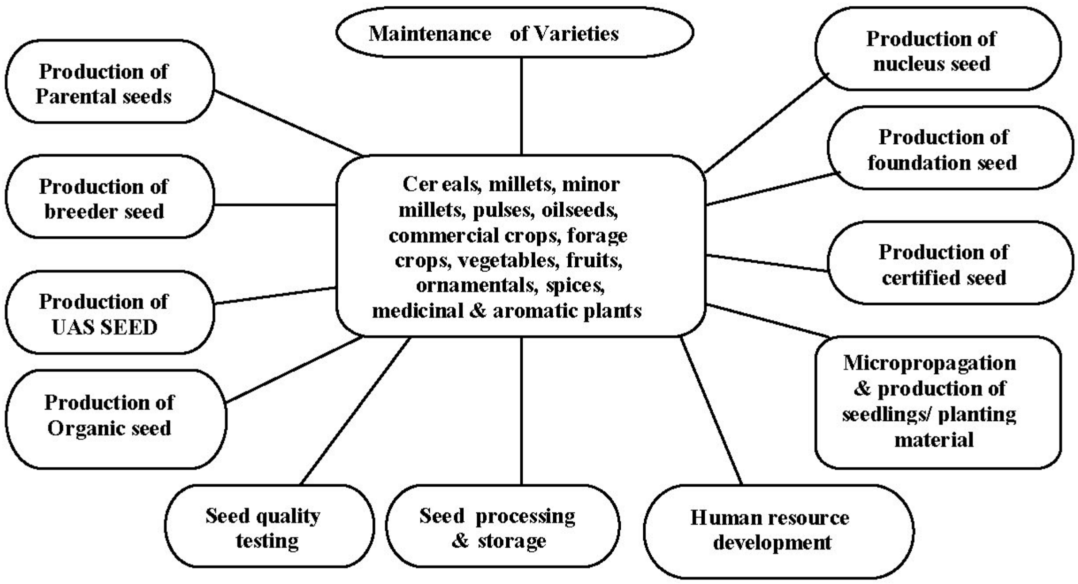


Figure 2. Crops and activities of the UAS Seed Unit

Although India is one of few countries where the seed sector has advanced in parallel with agricultural productivity, the availability of quality seed of improved varieties and hybrids is grossly inadequate and is a major constraint to enhanced production. Studies made by several workers very clearly indicate that with high volume-low value seed crops farmers use farm saved seeds for about 80% of the area sown; the area that represents old and obsolete varieties. This is more so in crops such as peanut, soybean and chickpea where seed costs alone may account for 50% of the total cost of production.

For popularizing newly developed varieties and promoting seed production of these varieties, seed mini-kits of new varieties are supplied to farmers. Seed exchange among farmers and seed producers is encouraged to popularize new/non traditional varieties. Seeds of newly developed varieties are made available to farmers with minimum time gap. In this regard, seed producing agencies are encouraged to tie up with research institutions for popularization and commercialization of these varieties. (Figure 3.)

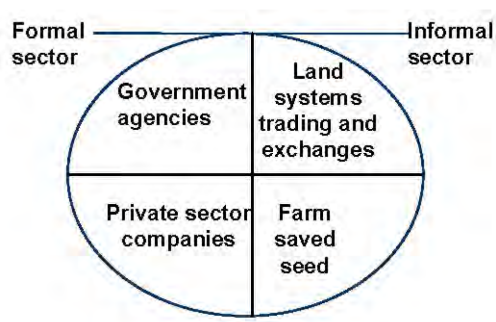


Figure 3. Seed supply systems

"Seed Village" concept

The gap between requirement of quality seeds and supply rate is large. The supply of seeds by public sector organizations and private agencies is insufficient to bridge the gap. The gap must be reduced by involving farmers in quality seed productions. A group of farmers or villages will be identified under the "Seed Village" concept to produce a particular crop/variety. Villages with a potential of producing seeds will be identified near to research stations for easier and higher quality multiplication of varieties of different crops.

 ISBN: 13: 978-0-615-70429-6

The main objective of the seed-village program is to involve farmers in seed production and thereby to make quality seed available earlier and at a reasonable price. Another objective is to demonstrate and saturate selected potential villages with improved varieties/hybrid seeds of major crops. The implementation of this program by UAS, Dharwad, has been most successful and this concept has been adopted by other institutions throughout India as the "Dharwad Model." Based on the model, UAS produces large quantities of quality seeds. University scientists monitor activities at all stages. The work also provides employment to seed growers and other villagers for seed processing, bagging and distribution.

For implementation of seed production under the Seed Village concept, villages with high potential for production are selected. Before starting the program, villagers are trained and educated about the Seed Village concept and its importance in disseminating improved production technologies and saturation of the area with quality seeds. UAS supplies genetically pure seeds of improved varieties on a credit or exchange basis. In addition, breeders of the respective crops along with Seed Unit scientists visit seed production plots in each village at 10-15 day intervals and provide technical guidance to the farmers. During the crop season, training programs are organized to educate the farmers on seed production skills. Field days and meetings are also organized by inviting all farmers of a village and of nearby villages to make them aware of improved varieties, the importance of quality seed in achieving increased yields, and providing information regarding the availability of seed. Of the seed produced 70-80% is purchased by the University for wider distribution under various government programs; the remaining 20-30%is retained by the producers who are encouraged to distribute the seed to relatives and neighbors within and outside their villages.

Under the Seed Village concept, besides the aim of popularizing improved varieties and production technologies, client oriented seed production is also undertaken. During the production programme, innovative techniques such as seed treatment with bio-agents and pest controls through IPM/bio-agent are addressed to minimize the cultivation cost.

Training on post harvest handling of produce is also encouraged and since scientists regularly visit the seed villages, problems faced by farmers in production of other crops are also addressed. This enables development of close scientist-farmer relationships resulting in transfer of new technologies, including information on varieties/hybrids, and feedback of new problems needing research solutions. In a few villages, the farmers have established Seed Growers Associations to strengthen their seed production activities.

Thus it is possible to improve the quality of farm saved seeds by improving farmers' capacity to produce, process and store quality seeds. The area, production and productivity of wheat in India have continuously grown since 1965 with the development of new high yielding varieties (HYVs), their large-scale seed production and adoption by farmers. More than 378 HYVs of bread, durum and emmer have been released since 1965 by central and state varietal release committees. This has required enormous increases in breeder and quality seed production to make new varieties available for large-scale adoption. It is essential to maintain the seed chain of breeder, foundation and certified seed production by active involvement of public and private seed agencies but with increased farmer participation. This strategy can help in increasing the seed replacement rate to replace old and obsolete varieties grown by farmers from farm-saved seeds. With new and proven seed enhancement techniques (e.g., polymer coating, accelerated aging, priming) it has been possible to boost fast-track transfer new high yielding varieties to farmers' fields and thereby to enhance overall productivity.

Before rust resistant wheat varieties are nationally registered and ready for release, a national strategy should be in place for the multiplication and distribution of quality seed of rust resistant varieties to replace the rust susceptible varieties. Production urgency should not compromise the quality of foundation/certified seeds. Many of the regions will therefore require training and some basic equipment to maximize the yield obtained from early generation seed multiplication. Support will be required for the nation-wide establishment of demonstration plots to popularize the varieties that will be released. Participatory farmer education methods have proved extremely effective in encouraging farmers with strong observations and decision-making abilities. Properly trained farmers will be a major part of implementation of national contingency plans. They can also help in early recognition and reporting of changes in disease severity and pathogen virulence in the field, and in understanding the risks associated with virulent strains and the importance of the various field management practices (e.g. planting dates, planting periods, choice of varieties) for disease control and yield improvement.

In order to strengthen national seed systems for rapid multiplication and distribution of resistant varieties, the following activities are emphasized:

- Work with national authorities to popularize adapted rust resistant varieties among farmers through seed campaigns, including field demonstrations
- Strengthen systems for early generation seed multiplication of rust resistant varieties in each country
- Develop and support a strategy for the multiplication and distribution of quality seed of rust resistant varieties to replace rust susceptible varieties through both the public and private sector
- Strengthen the Seed Certification Agency's database through a catalog of released varieties and information on quantities of certified seeds available and expected responses to current pathogen and pest populations
- Reach agreement with national authorities on the establishment of participatory methods such as Participatory Seed Production (PSP) to support wheat farmers in proper field management
- Support to identified or established farmer groups or PSPs through hands-on training/season-long participatory training
- Develop training and reference wheat management guides for farmers and facilitators based on local experience.

Conclusions

UAS, Dharwad has a vision to provide farmers in all the districts of Karnataka with quality seeds of improved varieties/hybrids through selected seed villages from which the seeds will spread to major cultivated areas within the shortest possible periods. This will enhance seed replacement rates and increase productivity of all major crops, including wheat. Karnataka, especially northern areas of the state has diverse climate, soil and other natural resources suitable for seed production and distribution. Potential areas with suitable natural resources can be identified and infrastructurally developed to make them "National Grids" to meet the seed requirements of neighboring states and other national regions, and even for export to other countries.

The rusts of wheat can be successfully controlled in Asia through a combination of strategies. Regional co-operation is essential for monitoring the pathogen populations and presence and movement of particular races. Information on the genetic basis of resistance is necessary will be necessary to maintain genetic diversity in farmers' fields. Traditional and molecular genetic research to further enhance understanding of slow rusting resistance based on minor, additive genes should receive priority. The targeted transfer of durable resistance into widely grown genotypes and the subsequent deployment of those derivatives is an attractive strategy for achieving long-term rust control.

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