REPORT

on

INTERNATIONAL SEMINAR ON PULSES AND WHEAT FOR FOOD SECURITY

February 25, 2018

Muhammad Nawaz Shareef University of Agriculture
MULTAN, PAKISTAN

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EXECUTIVE SUMMARY

Agriculture is the backbone of Pakistan; it contributes 19.5 percent in GDP and engages 42.3 percent labour force of the country. The problems of food security and agriculture should be viewed within the context of the broader structural transformation as Asia becomes increasingly urban and nonagricultural.

Keeping in view the importance of cereals and pulses and current food security and nutrition related challenges in Pakistan, the Department of Plant Breeding and Genetics and Department of Agronomy has organized an international Seminar on Pulses and Wheat for Food Security February 25, 2018. The seminar provided a platform for thought-provoking discussion on the said topic. The seminar began with the recitation of Holy Quran. The worthy Vice Chancellor, Prof. Dr. Asif Ali gave the thanking remarks to the chief guest Mr. Javaid Shah (Federal Minister of Irrigation), foreign delegation and all the distinguish guests in the seminar. He also discussed that how administration solve the water resource issue and how did they develop a successful agricultural system in Jalalpur- Pirwala. On behalf of the chief guest Mr. Javaid Shah (Federal Minister of Irrigation), Mr. Ibn-e-Hussain, IG Police (R) welcomed all foreign delegates, participants and the management team of the seminar on discussing such a meaningful topic. The seminar proceeded with the technical sessions on wheat and Pulses.

Wheat

(i) Innovative breeding and production strategies for wheat
(ii) Hybrid wheat for food security
(iii) Challenges and prospects of wheat cultivation in Pakistan

Pulses

(i) Temperature tolerance and yield in chickpea: optimizing phenology
(ii) Challenges and prospects of pulses cultivation in Pakistan
(iii) Microbial inoculation for sustainable production of legumes

The seminar cover all the major topics related to wheat and pulses and their role in alleviating the problems of food security. A number of renowned foreign and local scientists delivered talks during technical sessions.

The foreign scientists included Prof. **Prof. Dr. Richard Trethowan (**Director, IA Watson Research Centre, and Australia), **Dr. Chris Tapsell (**Global Wheat Breeding Lead at KWS, UK), **Dr. Jacob Lage (**Head of Wheat Pre-Breeding at KWS, UK) **and Dr. Nick Bird** (Research scientist at KWS, UK). While the local scientists included **Prof. Dr. Zulfiqar Ali (**Chairman, Department of Plant Breeding and Genetics), **Dr. Makhdoom Hussain (**Ex-Director Wheat Research Institute, AARI, Faisalabad), **Prof. Dr. Irfan Baig (**Dean, Faculty of Social Sciences and Humanities, MNSUAM), **Dr. Shahid Riaz Malik (**Program Leader Pulses, National Agricultural Research Center, Islamabad), **Dr. Khalid Hussain (**Director, Arid Zone Research Institute, Bhakkar), **Prof. Dr. Zahir Ahmad Zahir (**Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad). Overall the seminar was quite successful in addressing different issues related to wheat and Pulses. The foreign scientists also visited the hybrid wheat research trial along with other wheat research trial at University farm. The sessions were presided over by the scientists who drafted final recommendations for each technical session conducted after thorough discussion. The recommendations were presented by the session chairs individually.

RECOMMENDATIONS

- We have to develop our agricultural commodities in such a way that these products can sustain even in water stress conditions
- Genomic Selection promises to revolutionize wheat breeding for the future.
- Development of zone-specific wheat varieties suitable for different cropping systems under changed climate scenario.
- The microbial inoculation will be an effective tool for sustainable production of legumes.
- We should contribute in pulses production through promoting and sustaining consumption, supporting production and strengthening the value chain
- There is a need to develop varieties with higher yield potential that respond to improved management practices so as to meet the increasing demand of pulses.
- Emphasized on teamwork for the motive of food security with ever-memorable line

Seminar Venue

The seminar was held at Muhammad Nawaz Shareef University of Agriculture, Multan (MNSUAM). The modern city of Multan is the 6th largest city of Pakistan and is the center of Islamic mystical Sufi Culture. The city is considered one of the safest city for the foreign tourists and is well connected with the world through international air flights, and connected to rest of Pakistan through domestic air flights, railways and all type of public transport. The MNSUAM was established in 2012 and has been recognized by Higher Education Commission, Pakistan. Since then, it has emerged as a fast growing chartered public sector University that is aspiring to mark its name among the best agriculture universities in the country. The University distinctly aims to "provide systems and leadership in professional learning, research and outreach to promote agricultural production, nutrition, entrepreneurship and community service" to meet its mission of "food security and knowledge economy through intellectual and social transformation".

Technical program (25 February, 2018; Sunday)

Session 1. Wheat for Food Security

Chair: Dr. Noor-ul-Islam, CEO PARB

Co-chair: Dr. Makhdoom Hussain

Time	**Activity/Presentation**	**Resource Person**
9:00 am	The arrival of guests and registration	Respective committees
9:30 am	The inaugural session of spring festival	**Chief Guest**
9:45 am	Recitation from Holy Quran &Naat	
9:50 am	Welcome Address	**Prof. Dr. Asif Ali** Vice Chancellor, MNSUAM
10:00 am	Genomic strategies enhance genetic gain in practical wheat breeding	**Dr. Richard Trethowan** Director, IA Watson Research Centre, Australia
10:20 am	KWS – an independent, global seed company	**Dr. Chris Tapsell** Global Wheat Breeding Lead at KWS, UK
10:40 am	"Hybrid wheat for food security" – a UK funded research project	**Dr. Jacob Lage** Head of Wheat Pre-Breeding at KWS, UK
11:00 am	Tea Break	**-**
11:30 am	Molecular markers and resources used in KWS' wheat breeding programs	**Dr. Nick Bird** Research scientist at KWS UK
11:50 am	Status of Wheat in Punjab/Pakistan	**Dr. Makhdoom Hussain** Ex- Director Wheat Research Institute, AARI, Faisalabad.
12:10 pm	Challenges and prospects of wheat cultivation in Pakistan	**Dr. Javed Ahmad** Director Wheat Research Institute, AARI, Faisalabad.
12:30 pm	Architecting wheat for fog capturing	**Prof. Dr. Zulfiqar Ali** Chairman, Department of Plant Breeding and Genetics
12:50 – 2:00 pm	Lunch	-

Session 2. Pulses for Food Security

Chair: Dr. Richard Trethowan

Co-chair: 1) Dr. Zahir Ahmad Zahir 2) Dr. Shahid Riaz Malik

Time	**Activity/Presentation**	**Resource Person**
2:20 pm	Temperature tolerance and yield in chickpea: optimizing phenology	**Dr. Richard Trethowan** Director, IA Watson Research Centre, Australia
2:40 pm	Pulses breeding in Pakistan: current status and future needs	**Dr. Abid Mahmood** Director General (Agri. Research, Punjab)
3:00 pm	Importance of pulses on food security and poverty alleviation	**Prof. Dr. Irfan Baig** Dean, Faculty of Social Sciences and Humanities,MNSUAM
3:20 pm	Challenges and prospects of pulses cultivation in Pakistan	**Dr. Shahid Riaz Malik** Program Leader pulses National Agricultural Research Center, Islamabad
3:40 pm	Challenges and opportunities for chickpea seed production and procurement	**Dr. Khalid Hussain** Director, Arid Zone Research Institute, Bhakkar
4:00 pm	Microbial inoculation for sustainable production of legumes	**Prof. Dr. Zahir Ahmad Zahir** ISES, University of Agriculture, Faisalabad
4:40 pm	Vote of Thanks	**Prof. Dr. Zulfiqar Ali** Chairman, Department of Plant Breeding and Genetics, MNSUAM

1. Inaugural session

The seminar began with the recitation of Holy Quran by Hafiz Muzamil. Afterward, Prof. Dr. Hammad Nadeem Tahir started the inaugural session of the seminar and introduced the audience about the importance of pulses and wheat in securing food security. He invited Worthy Vice Chancellor MNSUAM, Prof Dr. Asif Ali, for welcome address.

Welcome Address by the Vice Chancellor

The worthy Vice Chancellor, Prof. Dr. Asif Ali gave the thanking remarks to the chief guest Mr. Javaid Shah (Federal Minister of irrigation), foreign delegation and all the distinguish guests in the seminar. He also discussed that how administration solve the water resource issue and how did they develop a successful agricultural system in Jalalpur- Pirwala.

He also emphasized on the collaborative research behavior among the scientific community to resolve the world food security concerns. He appreciated the role of KWS R&D wing and Dr. Richard with the overwhelming tribute on their great efforts in the development of successful hybrid wheat development and establishment of genomic selection models to increase the efficiency of breeding techniques.

Address by the Chief Guest

On behalf of the chief guest Mr. Javaid Shah (Federal Minister Irrigation), Mr. Ibn-e-Hussain, IG Police (R) welcomed all foreign delegates, participants and the management team of the seminar on discussing such a meaningful topic. He said that collaboration, co-operation among academia, farmers, industry, researchers and scientist can resolve emerging worldwide problems. He further told that scarcity of water is a big challenge and major threat to whole world and we have to develop our agricultural commodities in such a way that these products can sustain even in water stress conditions. One collective team effort can convert our deserts into the lush green fields. On the behalf of the Federal Minister, Mr. Ibn-e-

Hussain expressed his in a sentence that wishes you (scientific community) success in the field of Agriculture and Production.

2. Technical Session

Wheat for Food Security

The foreign delegate proposed different genomic selection strategies for developing resistance in wheat. They also explain how genomic selection is a new plant breeding method that uses statistical modeling to predict how a plant will perform, before it is field-tested. Novel statistical models and bioinformatics tools, combined with increasingly abundant genomic information, have enabled the deployment of prediction-based breeding methods such as Genomic selection.

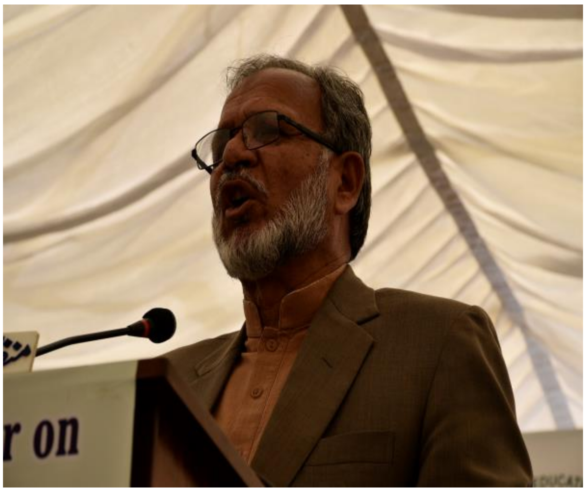
Genomic Selection promises to revolutionize wheat breeding for the future. Giving breeders the ability to select based on predictions rather than observations will result in much improved genetic gains and efficiency in wheat breeding.

They also briefed about “KWS an independent, Global Seed Company”. The KWS portfolio consists of a broad, proprietary, diversified gene pool for the development of agricultural crops. Research and development wing of the KWS focused on the cereals, sugar beet and maize (Americas and rest of the world). They also talk on “Hybrid Wheat for Food Security: *Halfway through the journey*. They pointed out that population explosion (10 billion people by 2055) is the key factor in the upcoming time and it is the challenge for the scientific community to address the concept of food security for the humanity. He also mentioned that this project is 5-year UK- funded project and having different global partners e.g. Norman Darvey, University of Agriculture Faisalabad, Muhammad Nawaz Shareef University of Agriculture Multan, University of Sydney and KWS. They also described the objectives of project that are given below.

1- Development of hybrids for testing in Pakistan, Australia and Europe
2- Improvement of Norman's hybrid system
3- Exploitation of heterosis in Australian and Pakistani germplasm

They emphasized the development of male sterile wheat through chemical hybridization agents, genetic engineered nuclear-encoded system and biological native trait systems (CMS & NMS). In the end, they emphasized on teamwork for the motive of food security with the ever-memorable line *"We should all feel blessed by the privilege of working together in peaceful environments so that we can contribute to food production in the poor and hungry nations on earth"*.

Whereas the local speakers presented status of wheat, challenges and prospects of wheat cultivation in Punjab/Pakistan. Pakistan obtained 26200 tons of wheat from area 9050 ha by the year 2016-2017. Ayyub Agriculture Research Institute, Faisalabad in the year 2016-2017, released six varieties of wheat; ujala-16, johar-16, gold-16, ihsan-16, fatehjang-16, anaj-17 and two barley varieties; jau-17 and s Sultan-17.



Future research directions; breeding for nutrition enhancement in wheat (genetics, bio-fortification and value addition) to overcome malnutrition problems, Development of zone specific wheat varieties suitable for different cropping systems under changed climate scenario (special focus on rice zone), development of stress resilient wheat varieties (drought, terminal heat stress, frost, salinity and disease) and development of nutrient efficient varieties and integrated plant nutrient management system.

Session Pulses for Food Security

Dr. Richard Trethowan gave a second talk on ‘Chickpea pre-breeding and research for temperature tolerance’. He described the importance of grain crops for sustainable Agriculture and their existence in Australia as wheat 60%, barley 19%, canola 8%, pulses 7%, oats 4% and sorghum 2%.

He proposed that National Research HUB focused on improving grain legume productivity and agricultural sustainability. Enhance N2-fixation of grain legumes for annual and rotational crop production.

The local speakers provided the information regarding the ‘Importance of Pulses in Food Security'. They explained that Pakistan is one of the world's largest producers of the agricultural commodities and ranks 77th out of 109 on the Global Food Security Index. Six out of 10 Pakistanis are food insecure.

The scope of pulses in reducing the food insecurity, pulses can play an important role for the food security of large proportions of populations, particularly in Latin America, Africa and Asia, where pulses are part of traditional diets and often grown by small farmers. Pulses can contribute significantly in addressing hunger, food security, malnutrition, environmental challenges and human health. In the end, he concluded that we should contribute in pulses production through promoting and sustaining consumption, supporting production and strengthening the value chain. Dr. Khalid Hussain, Director Arid Zone Research Institute Bhakkar, highlighted the importance of seed in successful crop production. The role of seed in providing sustainable crop production is mainly through new varieties. Dr. Zahir A. Zahir described co-inoculation with Rhizobia and PGPR containing ACC-deaminase. A novel discussion was made regarding multi-strain bio-fertilizer for sustainable production of pulses (Mung bean, Chickpea & Lentil). He also proposed that by using the product rhizogold, yield could be increased 16% in mungbean and 19% in chickpea at farmers' field level. Therefore, he concluded the following information that microbial inoculation is an effective tool for sustainable production of legumes. Application of Rhizobium significantly improved, nodulation efficiency of legumes, eventually enhanced growth and yield through various mechanisms.

Concluding Session

Dr. Noor-ul-Islam, Director Pakistan Agricultural Research Board (PARB), applauded the efforts of Vice Chancellor MNS-UAM for successfully conducting an international seminar on importance of pulses and wheat in food security. He praised the efforts of faculty, students and administrative staff of the University in this regard.

He assured that PARB will continue to support the scientific projects of MNS-UAM and would continue its collaboration with the University.

Vote of Thanks

Prof. Dr. Zulfiqar Ali (Chairman, PB&G) thanked everyone especially the foreign scientists who came a long way to make this conference successful. He also applauded the support of government research institutions and private sector firms for holding International Seminar on Pulses and Wheat for Food Security. Prof. Dr. Zulfiqar Ali congratulated everyone on successful completion of conference.

Distribution of Souvenirs

The invited speakers and oral presenters were awarded with shields and certificates by Dr. Noor-ul-Islam and Worthy Vice Chancellor MNS-UAM, Prof. Dr. Asif. Ali.


SPONSORS

The following agencies sponsored the conference.

1. Punjab Agriculture Research Board
2. The University of Sydney
3. Australian Centre for International Agricultural Research
4. USAID
5. DFID

List of Participants

Sr. #	Name	Designation
1.	Nasir Abbas	Student M.Sc PBG 4th
2.	Dr. Baqir Sb	AP. SES
3.	Dr. Muqarb Ali	AP. AGRO
4.	M. Naeem Akhtar	PhD (Scholar) SES
5.	Shahid Mushtaq	Bsc
6.	Dr. Jaffar Ali	PBG- UAF
7.	Mehmood Ijaz	Bsc. SST
8.	Waqas	Bsc. SST
9.	DR. Ummara	AP
10.	Ayesha Ajmal	Bsc. Biotech
11.	Dr. Tanveer ul Haq	SES HOD
12.	Dr.Imran	SES
13.	Fatima Mazhar	Biotech
14.	Mirza Abid Mehmood	Lecturar Phd Scholar
15.	Rao Umar Akram	Lecturar Phd Scholar
16.	M. Waqar Sabir	Msc PBG
17.	M. Afzal	Phd. Entomology
18.	Noraiz Qamar	B.sc AGRO
19.	Tayyaba Nisar	Biotech
20.	Maryam	SST
21.	Mudassir Rafiq	PBG. Bsc
22.	Nouman Khalid	PBG. Bsc
23.	Imran Ullah	PBG. Bsc
24.	Dr. M. Habib ur Rehman	AP. AGRO
25.	Dr. Abid Ali	AP. ENTO
26.	Dr. Manan	AP. BBA
27.	Asif Mehmood Arif	Lecturar UAM
28.	Dr. Arsalan	AP. UAM
29.	Ali Amar	Phd. PBG
30.	Shoaib Llaqat	Phd. PBG
31.	Dr. Ghulam Haider	AP
32.	Farhan Ullah Khan	Bsc. AGRO
33.	M. Nasir	Bsc. AGRO
34.	Dr. Nasir Nadeem	AP. Agri Economics
35.	Saba Maryam	Phd. PBG
36.	Farukh	Phd. PBG
37.	Dr. Salman	PBG
38.	Dr. Ali BAkh	PBG. Ghazi Uni DG khan
39.	Areeba Fatima	PBG
40.	Muneeba Haider	PBG
41.	Dr. Nadia Iqbal	AP. MNS-UAM
42.	Babar Farid	Lecturer MNS-UAm
43.	Zoha Abeer	Msc. 4th. PBG
44.	Usman Jamshed	Lecturer UAM
45.	Dr. Mirza A. Qayyum	AP. UAM
46.	M. Ali Sher	Lecturer UAM

47.	Dr. M. Hammad Nadeem	Professor
48.	Mudassir Aziz	Lecturer AGRON
49.	Dr. Khurram Mubeen	AP. AGRON
50.	Dr. Abdul Ghaffar	AP
51.	Mr. M. Usman	Lecturer PBG UAM
52.	Dr. M. Shahbaz	AP
53.	Dr. Umar Farooq	AP
54.	Ms. Afshan Eman	Lecturer FST
55.	MR. M. Arif	Lecturer SES
56.	Dr. Amar Matloob	AP. AGRON
57.	Mr. Furqan Ahmed	Lecturer PBG
58.	Dr. Kashif Razzaq	AP. Horticulture
59.	Daniyal Ahmad	Msc. AGRON
60.	Dr. Sarmad Frogh Arshad	AP. BIOTECH PBG
61.	Ghulam Mustafa	MSc. AGRON 2nd
62.	Dr. Umer Ijaz	AP. Economics
63.	Sumaya Riaz	Student BZU
64.	Madiha Ashraf	Student BZU. Bsc
65.	Dr. M. Ameen	AP. HORTI
66.	Ahmed Ibrahim	Student Bsc
67.	Ishrat Zaman	St. M.Phil AGRO
68.	M. TAyyab	Phd
69.	Shahzad Ahmad Junaid	Phd
70.	Shafia Saba	Phd. ENTO
71.	Kaleem Rao	Bsc
72.	M. Usman	Bsc
`73.	Saima Rashid	Lecturer. Botany PBG
74.	Dr. Unsar Naeem	Lecturer
75.	Umair Rasool Azmi	PBG Bsc
76.	Abdul Manan	PBG. Project Officer
77.	Maria Iqbal	M.Phil PBG
78.	Rana. M. Zia ul Haq	Progressive Farmer
79.	M. Shafiq	Pulses Botanist FSD
80.	M. Rafiq	Director Pulses FSD
81.	M. Saleem	AB FSD(Pulses)
82.	Amir Afzal	BIO 6th
83.	M. Rafi	BIO
84.	Asim Razzaq (No Money)	
85.	Saad Parvaiz	M.phil Student. AGRON
86.	M. Arsaln Khalid	Phd. PBG
87.	Hafiz M. Amir	M.Phil AGRON
88.	Mahnoor Naeem	PBG. Bsc
89.	M. Arsalan	PBG. BSc
90.	H.M. Waqas	PBG. BSc
91.	Tehmina Sattar	Biotech. BSc
92.	Dr. Shahid Iqbal	AP. AGRON
93.	Dr. RAO M. Ikram	AP. AGRO
94.	Tuba Arshad	PBG

95.	Bahar Ali	M.Phil PBG
96.	Marwaah	Biotech
97.	Taiyba Anwar	BIO 6th
98.	Abdul Rehman	ENTO 6th
99.	Dr. M. Asif Raza	VMD
100.	Mr. M.Abu Bakar	Lecturer PBG
101.	Mr. Umar Iqbal	Lecturer PBG
102.	Dr. Zulfiqar Ali	Professor PBG`
103.	Ms. Plosha Khanum	Lecturer
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106.	Ch. Hanif	4B Seed Form
107.	Rashid Ali	Editor Info
108.	M. Azam	Photography
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112.	M. Khursheed	Farmer
113.	Mulazim Hussain	Farmer
114.	Dr. Abu Bakar	AP. UAF
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116.	Imran Ullah	Student
117.	Shameer	Studnt
118.	Dr. M. Aslam	UAF
119.	Ghulam Farid Akhtar	
120.	Khawaja M Shoaib	
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122.	Dr. Masood	RARI Bahawalpur
123.	Dr. Habib ur Rehman	
124.	Dr. Amir Nawaz	Chairman Horticulture
125.	Mrs. Amir Nawab	BZU
126.	M. Rizwan	
127.	Sajjad Hassan	Farmer from Bakhar
128.	Rashid Manzoor	Major Marketing(FFC)
129.	Dr. Faqeer Hussain Anjum	Agronomist
130.	Rana Ahmed Muneer	Director Agri Extension
131.	Dr. Noor ul Islam	CE PARB
132.	Abbas Aziz	Fouji (FFC)
133.	Qamar Shakeel	Botanist Fodder Research
134.	Dr. M. Sajjad	Group head ORGA
135.	Dr. Israr Saeed	Chairman NASF
136.	Dr. Bashir Javeed Paracha	Ex Assistant Prof of Dermatology
137.	Sabir Ali Mirza	PTV Reporter
138.	Naveed Asmal Khaloon	AD information
139.	Mudassir Irshad	ARM,PMG,P1P1P Multan
140.	Niaz Hussain	ARO, AZRI Bhawalpur
141.	M. Kashif	Former
142.	Jamil u din Bujdar	Former

143.	Dr. M. Sohail	AP. DG Khan University
144.	Awais Rasheed	
145.	Abdur Rehman	SO
146.	Sajjad Ullah Malik	SSO 4B
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148.	Dr. Abdul Qayyum	PBG, BZU
149.	Dr. Sajid Farid	FFC
150.	Hasan Yasar	Student BSc
151.	Seemab Shafqat	Student BSc
152.	Jamshed Nouman	Student BSC
153.	M. Shabbir	Student BSC
154.	Misbah Afzal	Student BSC
155.	Zulkifl Ashraf	Student BSC
156.	M. Shoaib	Student BSC
157.	Sami Ullah	Student BSC , AGRI 4th
158.	Dr. Irfam Baig	AP, MNSUAM
159.	Rashid Manzoor	Biotech 6th
160.	Dr. Altaf Hussain	CB(CRS),BWP
161.	Dr. Irum Aziz	Lecturer PBG, DGK
162.	Farjaad Mujtaba	Entomology 6th
163.	M. Nadeem	Biotech 6th
164.	Aqeel Haider	BSc 4th
165.	Waqas Ali	BSc (Hons)
166.	M. Nazim	MSc, Agronomy
167.	Asmatullah	MSc Agronomy
168.	M. Afzal	Farmer
169.	Waqas Ali	FST 6th
170.	Ali Hasnain	FST 6th
171.	Asjid Mehr	Biotech 6th
172.	Riaz Ahmed	Rajab Sons Eng
173.	Dr. Zahir Ahed Zahir	Prof SES , UAF
174.	Ammadu-din	PBG, 8th
175.	M. Irfan	Rathan Maize
176.	M. Sajjad	Rathan Maize
177.	Arsalan Mehmood	Rathan Maize
178.	M. Aqib	Msc (Hons),2nd Semester,AGRO
179.	M. Zahid Iqbal	BSc (Hons), Semester,Agriculture 2nd
180.	Umair Arif	BSc (Hons), Semester,Agri. B 2nd Semester
181.	Usama Ahmad	BSc (Hons), Semester,Agri. B 2nd Semester
182.	Shafa Nayas	MSc (Hons), Horticulture
183.	Zermeen Tariq	BSc (Hons), AGRI
184.	Arzoo Azam	Employ Horticulture
185.	Zohaib Asghar	Student
186.	Kashif Ali	Student
187.	M. Arshad	Student BSc
188.	Aman Ullah	Student BSc
189.	Ahmad Ibrahim Jalali	Student BSc
190.	Hassan Raza	Student BSc

191.	M. Noor Muzamil	Student BSc
192.	Arsalan Ahmad	Student BSc
193.	M. Siraj	Student BSc
194.	H. Sami Ullah	Student BSc
195.	Sohail Yousaf	Student BSc
196.	M. Insaf	Student BSc
197.	Arslan Abid	Student BSc
198.	M. Shahbaz	Student BSc
199.	Nida Munir	FST (6^{th})
200.	Mishal Malik	FST (6^{th})
201.	Rimsha Umar	FST (6^{th})
202.	Misbah Sharif	FST (6^{th})
203.	Waqas Ali	FST (6^{th})
204.	Ali Hasnain	FST (6^{th})
205.	M. Zaki Khan	FST (6^{th})
206.	M. Majid Ali	MSc (2^{nd}), PBG
207.	Huda Bilal	6^{th} Entomology
208.	Sarmad Malik	6^{th} Entomology
209.	Munir Ahmad	Student/MSc (Hons)
210.	M. Umer Nawaz	Student/Fruit Processing & Preservation Sort Course
211.	M. Rafiqe	Student/Fruit Processing & Preservation Sort Course
212.	M. Bilal Riaz	Student/MSc (Hons),AGRO
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215.	Saba Wajid	Student/MSc (Hons),SES
216.	Talha Rasheed	Student/MSc (Hons),SES
217.	Mehak Fatima	Student/MSc (Hons),SES
218.	Syed Akash Murtaza	Student/MSc (Hons),SES
219.	Hunzala Shahid	Student/BSc, AGRI
220.	Qasim Bhatti	Owner of Farms
221.	Sajid Rashid	Farmer
222.	Inam Ullah	Farmer
223.	Imran	Farmer
224.	Dr. Dilburgh M	Farmer
225.	Dr. M. Qadir Ahmad	AP
226.	Dr. Nazar Farid	AP
227.	Dr. Hafiz M. Nasrullah	Agronomist, A.R.S.,Khanewal
228.	M. Luqman	Agronomic Research Station,Khanewal
229	M. Rafiq	Asst. Dist Officer
230	Qaswar Abbas	Farmer
231	Najeer Hussain	Duasa Foundation
232	Mirza Asad	Veterinary BZU
233	M. Akmal Khan	Veterinar BZU
234	Dilshad	Student
235	M. Naeem Wazir	Farmer
236	Ghulam Farid	Ph.D Scholar
237	Ijaz Hussain	DVM-BZU

238	M. Ishaq Zain	Commerce
239	Ruqaya Masood	Soil Science
240	Abeer Nawaz	Soil Science
241	Abdul Ghafoor	Farmer
242	M. Falah	Farmer
243	Riaz Hussain	Asst. Abu Bakar Hall
244	M. Imran	Electrician
245	M. Safdar	Agri-BZU
246	Sheraz Abid	FVS-BZU
247	Dr. Abid Hussain	AP-MNS-UAM
248	Kamran	Farmer
249	M. Tahir Habib	Student
250	Abdul Rasheed	Student, BS Math
251	M. Awais Anjum	MSc(Hons),FST
252	Nabeel Munir	BS-IT,MNSUA
253	Hassan Mouvia	BS-IT,MNSUA
254	Javid ur Rehman	Agri-BZU
255	M. Imran	Farmer
256	M. Shafiq	Student
257	Fatehullah	Student
258	Gulzar Ahmed	Farmer
259	Shah Fahad Hashmi	Student
260	Ameer Hamza	Student
261	M. Adnan	Farmer
262	Nadeem Akhtar	Farmer
263	Ghulam Abbas	Farmer
264	M. Shahzad	Farmer
265	Gulzar Ahmad	Farmer
266	Noor Muhammad	Farmer
267	Rashid Mukhtar	Ph. D Scholar
268	M. Farooq	Farmer
269	Qadir Mahmood	Sun Crop
270	Irshad Ahmad	Farmer
271	M. Iqbal	Farmer
272	Murtaza	Soil science
273	Ghulam Farid	Pesticide Business
274	M. Tariq	DVM
275	Touqeer Aslam	Farmer
276	Ali Abbas	Student
277	Adnan Fareed	Soil & Environmental Sciences
278	M. Amir	Farmer/Student
279	Ahsan ul Haq	Agriculture
280	Dr. Aamer	LSDD
281	M. Faisal Azeem	Agri, Business & Marketing
282	Shahzad Saleem	Soil Science
283	Sajid Ghafoor	Entomology
284	Azhar	Farmer
285	Zafar Abbas	Agri Extension

286	M. Umar Saleem	Agriculture
287	M. Majeed	Agriculture
288	Shah Jahan Bukhari	ARO Bahawalpur
289	Numan Khalid	Student
290	Muhammad Arslan	Student
291	Hafiz Muhammad Waqas	Student
292	Muhammad Tayyab	Student
293	Mudassir rafiq	Student
294	Mahnoor Naeem	Student
295	Tayyaba	Student
296	Areeba Fatima	Student
297	Robina Aziz	Student
298	Tuba arshad	Student
299	Usman akram	Student
300	Hafiz Mehmood	Student
301	Noraiz	Student
302	Hafiz Waseem	Student
303	Ahmad Nasir	Student
304	Jawad afzal	Student
305	Tasweeb	Student

Department of Public Relations & Publication's MNS-UAM

روزنامہ پاکستان ملتان

THE DAILY PAKISTAN MULTAN

جلد 14 | شمارہ 41

نواز شریف زرعی یونیورسٹی کلچرل نائٹ' ثقافتی گیت و رقص پیش

پاکستان میں پانی کی کمی کے موضوع پر خصوصی ٹیبلو پیش' حاضرین نے بھرپور سراہا

ملتان (سپیشل رپورٹر) محمد نواز شریف زرعی یونیورسٹی میں سپرنگ فیسٹیول 2018 کے سلسلے میں کلچرل نائٹ کا اہتمام کیا گیا۔ جس کے مہمان خصوصی وائس چانسلر جامعہ پروفیسر ڈاکٹر آصف علی تھے جبکہ کلچرل نائٹ میں ڈائریکٹر پری بریڈنگ ڈاکٹر جیکب لیگ (Jacob Lage)، ریسرچ سائنٹسٹ ڈاکٹر نیک برڈ (Dr. Nick Bird)، گلوبل ویٹ بریڈنگ لیڈ ڈاکٹر کرس ٹیپسل (Dr. Chris Tapsell) اور یونیورسٹی آف سڈنی، آسٹریلیا، سے تعلق رکھنے والے پروفیسر ڈاکٹر رچرڈ ٹریتھاون (Dr. Richard Trethowan)، پروفیسر ڈاکٹر خدائے برگی (Dr. Khuda-E-Bargi)، ازبکستان نے خصوصی طور پر شرکت کی۔ کلچرل نائٹ میں محمد نواز شریف زرعی یونیورسٹی ملتان کے طلباء و طالبات کی جانب سے پاکستان کی مختلف ثقافتوں کی نمائندگی کیلئے ثقافتی رقص، ٹیبلوز اور ثقافتی گیت پیش کئے گئے۔ کلچرل نائٹ میں طلباء و طالبات نے ثقافتی لباس زیب تن کئے جبکہ اس کے علاوہ کلچرل نائٹ میں پاکستان میں پائی جانے والی مختلف ثقافتوں کے سٹالز بھی لگائے گئے۔ کلچرل نائٹ میں طلباء نے بلوچی ڈانس، پنجابی بھنگڑے، پختون رقص اور سندھی ڈانس کئے۔ کلچرل نائٹ میں پاکستان میں پانی کی کمی کے حساس موضوع کے بارے میں بھی خصوصی طور پر آگاہی ٹیبلو پیش کیا گیا جسے حاضرین نے سراہا۔ اس موقع پر پرو وائس چانسلر جامعہ پروفیسر ڈاکٹر اشتیاق احمد رجوانہ، ڈین فیکلٹی آف ایگریکلچر پروفیسر ڈاکٹر شفقت سعید، ڈین فیکلٹی آف سوشل سائنسز پروفیسر ڈاکٹر عرفان احمد بیگ، ڈائریکٹر اورک پروفیسر ڈاکٹر ذوالفقار علی، ڈائریکٹر کیو ای سی پروفیسر ڈاکٹر حماد ندیم طاہر سمیت جامعہ کے فیکلٹی، سٹاف اور طلباء و طالبات کی کثیر تعداد نے شرکت کی۔

ملتان: سپرنگ فیسٹیول کا افتتاح وفاقی وزیر برائے آبی وسائل سید جاوید علی شاہ کر رہے ہیں

نواز شریف زرعی یونیورسٹی میں سپرنگ فیسٹیول کا آغاز' گندم، دالوں کی افادیت بارے سیمینار

ماہرین نے آن پلسز اینڈ ویٹ فار فوڈ سکیورٹی کی آگاہی دی' وفاقی وزیر جاوید شاہ و دیگر کی شرکت

ملتان (سپیشل رپورٹر) وائس چانسلر محمد نواز شریف زرعی یونیورسٹی پروفیسر ڈاکٹر آصف علی نے کہا کہ سپرنگ فیسٹیول 2018 کا انعقاد جامعہ کی بہت بڑی کامیابی ہے۔ انٹرنیشنل سیمینار آن پلسز اینڈ ویٹ فار فوڈ سکیورٹی منعقد کروانے کا بنیادی مقصد دالوں اور گندم کی اہمیت اجاگر کرنا تھا۔ گندم پاکستان کی سب سے اہم فصل ہے جس کا استعمال سب سے زیادہ ہے۔ بہترین انسانی صحت کیلئے گوشت کے ساتھ ساتھ گندم اور دالوں کا استعمال ضروری ہے وہ گزشتہ روز انٹرنیشنل سیمینار آن پلسز اینڈ ویٹ فار فوڈ سکیورٹی سے خطاب کر رہے تھے۔ انہوں نے مزید کہا کہ اس فیسٹیول میں لوگوں کیلئے فیسٹیوٹی کے ساتھ ساتھ آگاہی سیشنز کا انعقاد کیا جائے گا قبل ازیں محمد نواز شریف زرعی یونیورسٹی ملتان کی جانب سے منعقدہ سپرنگ فیسٹیول 2018 کے پہلے روز انٹرنیشنل سیمینار آن پلسز اینڈ ویٹ فار فوڈ سکیورٹی کا انعقاد کیا گیا۔ انٹرنیشنل سیمینار میں تفصیلی طور پر بین الاقوامی سائنسدانوں کی جانب سے پریزنٹیشنز اور آگاہی سیشنز کا انعقاد کیا گیا۔ انٹرنیشنل سیمینار (بقیہ نمبر 9 صفحہ 12 پر)

DAILY DUNYA MULTAN www.dunya.com.pk

روزنامہ دنیا ملتان

MONDAY, FEBRUARY 26, 2018

جلد نمبر 7 | شمارہ 56

نواز شریف زرعی یونیورسٹی میں طالبات ثقافتی شب میں ٹیبلو پیش کرتے ہوئے

نواز شریف زرعی یونیورسٹی میں سپرنگ فیسٹیول، ثقافتی شب

جاوید علی شاہ، ڈاکٹر آصف علی نے پودا لگایا، عالمی سائنسدانوں نے مقالات پیش کئے

ملتان (بیورو رپورٹ) محمد نواز شریف زرعی یونیورسٹی میں سپرنگ فیسٹیول 2018 کا افتتاح وفاقی وزیر برائے آبی وسائل سید جاوید علی شاہ نے وائس چانسلر پروفیسر ڈاکٹر آصف علی کے ہمراہ جامعہ میں پودا لگا کر کیا۔ انٹرنیشنل سیمینار آن پلسز اینڈ ویٹ فار فوڈ سکیورٹی میں ڈائریکٹر پری بریڈنگ ڈاکٹر جیکب لیگ، ریسرچ سائنٹسٹ ڈاکٹر نیک برڈ، گلوبل ویٹ بریڈنگ لیڈ ڈاکٹر کرس ٹیپسل اور یونیورسٹی آف سڈنی (آسٹریلیا) (صفحہ 11 بقیہ نمبر 6)

وفاقی وزیر جاوید علی شاہ اور ڈاکٹر آصف علی نواز زرعی یونیورسٹی میں سٹال کا معائنہ کرتے ہوئے

باقاعدہ تصدیق شدہ اشاعت ABC CERTIFIED پاکستان کے سب سے زیادہ

THE DAILY JANG MULTAN

روزنامہ جنگ ملتان

بانی...... میر خلیل الرحمٰن

THE DAILY JANG MULTAN 26 FEBRUARY 2018

جلد 16	پیر 9 جمادی الثانی 1439ھ 26 فروری 2018ء 13 پھاگن 2074ب	شمارہ 78

ملتان: نواز شریف زرعی یونیورسٹی میں سپرنگ فیسٹیول 2018ء کا افتتاح

ملتان (سٹاف رپورٹر) نواز شریف زرعی یونیورسٹی میں سپرنگ فیسٹیول 2018ء کا افتتاح ہوا، وفاقی وزیر برائے آبی وسائل سید جاوید علی شاہ نے وائس چانسلر جامعہ پروفیسر ڈاکٹر آصف علی کے ہمراہ جامعہ میں پودے لگایا، اس موقع پر وفاقی وزیر نے جامعہ کی جانب سے بنائے گئے ہائیڈروپانک یونٹ کا بھی افتتاح کیا، سپرنگ فیسٹیول کے پہلے روز انٹرنیشنل سیمینار آن پلسز اینڈ ویٹ فار فوڈ سکیورٹی کا انعقاد کیا گیا، انٹرنیشنل سیمینار میں ڈائریکٹر پری بریڈنگ ڈاکٹر جیکب لیگ (Jacob Lage)، ریسرچ سائنٹسٹ ڈاکٹر نک برڈ (Dr. Nick Bird)، گلوبل ویٹ بریڈنگ لیڈ ڈاکٹر کرس ٹپسل (Dr. Chris Tapsell) اور یونیورسٹی آف سڈنی، آسٹریلیاء سے تعلق رکھنے والے پروفیسر ڈاکٹر رچرڈ ٹریتھاؤن (Dr. RichardTrethowan)، پروفیسر ڈاکٹر خدائے برگی (Dr. Khuda-E-Bargi)، ازبکستان، ڈاکٹر مخدوم حسین، محمد رفیق، پروفیسر ڈاکٹر ذوالفقار علی، ڈاکٹر عرفان احمد بیگ، ڈاکٹر شاہد ریاض ملک، ڈاکٹر خالد حسین، ڈاکٹر ظہیر احمد ظہیر نے لیکچرز دیئے۔

DAILY EXPRESS

روزنامہ ایکسپریس ملتان

MONDAY, FEBRUARY 26, 2018

پاکستان کے 11 شہروں سے بیک وقت شائع ہونے والا واحد اخبار

جلد 16 شمارہ 193 | پیر 9 جمادی الثانی 1439ھ 26 فروری 2018ء 14 پھاگن 2074ب، صفحات 16 قیمت 15 روپے

نواز شریف زرعی یونیورسٹی میں سپرنگ فیسٹیول کا افتتاح

ملتان (نمائندہ ایکسپریس) محمد نواز شریف زرعی یونیورسٹی میں سپرنگ فیسٹیول کا افتتاح وفاقی وزیر برائے آبی وسائل جاوید علی شاہ نے وائس چانسلر جامعہ پروفیسر ڈاکٹر آصف علی کے ہمراہ جامعہ میں پودے لگا کر دیا۔ جامعہ کی جانب سے بنائے گئے ہائیڈروپانک یونٹ کا افتتاح بھی کیا۔ ڈاکٹر جیکب لیگ، ریسرچ سائنٹسٹ ڈاکٹر نیک برڈ، گلوبل ویٹ بریڈنگ لیڈ ڈاکٹر کرس ٹپسل اور یونیورسٹی آف سڈنی، آسٹریلیا سے تعلق رکھنے والے پروفیسر ڈاکٹر ریچرڈ ٹریتھاؤن، پروفیسر ڈاکٹر خدائے برگی، ازبکستان، ڈاکٹر مخدوم حسین، محمد رفیق، پروفیسر ڈاکٹر ذوالفقار علی، ڈاکٹر عرفان، شاہد ریاض، خالد حسین، ڈاکٹر ظہیر احمد، اشتیاق رجوانہ بھی موجود تھے۔

DAILY NAWA-I-WAQT MULTAN

روزنامہ نوائے وقت ملتان

بانی حمید نظامی مرحوم

معمار مجید نظامی مرحوم

ایڈیٹر رمیزہ مجید نظامی

لاہور/کراچی/راولپنڈی/اسلام آباد اور ملتان سے بیک وقت شائع ہوتا ہے

جلد	پیر 9 جمادی الثانی 1439ھ 26 فروری 2018ء 14 پھاگن 2074ب	صفحات	رجسٹرڈ نمبر سی پی ایل	شمارہ
40	فون 4545571-74/UAN111-222-007 قیمت 15 روپے	16	96	246

ملتان: وفاقی وزیر جاوید علی شاہ کو نواز شریف زرعی یونیورسٹی کے دورہ کے موقع پر بریفنگ دی جا رہی ہے

ملتان: نواز شریف زرعی یونیورسٹی میں سپرنگ فیسٹیول کے سلسلے میں منعقدہ کلچرل نائٹ میں طلبہ وطالبات ثقافتی رقص پیش کرتے ہوئے دوسری جانب ملک میں پانی کی قلت کے مسئلے کو ٹیبلو کی صورت میں اجاگر کیا جارہا ہے

MEMBER APNS | کامیاب صحافت کے 44 سال | ABC CERTIFIED

ملتان، لاہور اور کراچی سے بیک وقت شائع ہونے والا کثیر الاشاعت آزاد قومی اخبار

Daily AFTAB Multan

روزنامہ آفتاب ملتان

چیف ایڈیٹر: ممتاز طاہر

ایڈیٹر: اسد ممتاز

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جلد نمبر 44 | پیر 9 جمادی الثانی 1439ھ 26 فروری 2018ء 14 پھاگن 2073 ب | صفحات 8 | قیمت 10 روپے | شمارہ نمبر 180

نواز شریف زرعی یونیورسٹی میں سپرنگ فیسٹیول، جاوید علی شاہ نے افتتاح کیا

وفاقی وزیر برائے آبی وسائل نے وائس چانسلر ڈاکٹر آصف علی کے ہمراہ جامعہ میں پودے لگائے، ہائیڈروپانک یونٹ کا بھی افتتاح

فیسٹیول میں آگاہی سیشنز کا انعقاد کیا جائے گا تاکہ لوگوں کو خوشی کے ساتھ ساتھ فائدے مند معلومات حاصل ہوسکیں، وی سی کا خطاب

ملتان (زرعی رپورٹر) محمد نواز شریف زرعی یونیورسٹی میں سپرنگ فیسٹیول 2018 کا افتتاح وفاقی وزیر برائے آبی وسائل سید جاوید علی شاہ نے وائس چانسلر جامعہ پروفیسر ڈاکٹر آصف علی کے ہمراہ جامعہ میں پودے لگا کر کردیا۔ سپرنگ فیسٹیول 2018 کا باقاعدہ آغاز تلاوت قرآن پاک سے ہوا۔ سپرنگ فیسٹیول 2018 کے موقع پر وفاقی وزیر برائے آبی وسائل سید جاوید علی شاہ نے جامعہ کی جانب سے بنائے گئے

باقی صفحہ 7 بقیہ نمبر 7

ملتان: محمد نواز شریف زرعی یونیورسٹی میں سپرنگ فیسٹیول 2018 کے افتتاحی روز وائس چانسلر پروفیسر ڈاکٹر آصف علی خطاب کر رہے ہیں

ملتان: سپرنگ فیسٹیول 2018 کا افتتاح وفاقی وزیر برائے آبی وسائل سید جاوید علی شاہ کر رہے ہیں

بقیہ | 7

...نک یونٹ کا افتتاح بھی کیا اور ہائیڈروپانک یونٹ کا معائنہ بھی... محمد نواز شریف زرعی یونیورسٹی ملتان کی جانب سے منعقد سپرنگ فیسٹیول 2018 کے پہلے روز انٹرنیشنل سیمینار آن پلسز اینڈ ویٹ فار فوڈ سیکیورٹی کا انعقاد کیا گیا۔ انٹرنیشنل سیمینار میں تفصیلی طور پر بین الاقوامی سائنسدانوں کی جانب سے پریزنٹیشنز اور آگاہی سیشنز کا انعقاد کیا گیا۔ انٹرنیشنل سیمینار آن پلسز اینڈ ویٹ فار فوڈ سیکیورٹی میں ڈائریکٹر پری بریڈنگ ڈاکٹر جیکب لیگ (Jacob Lage)، ریسرچ سائنٹسٹ ڈاکٹر نک برڈ (Dr. Nick Bird)، گرین ویٹ بریڈنگ لیڈ ڈاکٹر کرس ٹیپسل (Dr. Chris Tapsell) اور یونیورسٹی آف سڈنی آسٹریلیا سے تعلق رکھنے والے پروفیسر ڈاکٹر رچرڈ ٹرےتھوان (Dr. Richard Trethowan)، پروفیسر ڈاکٹر خدائے برگی (Dr. Khuda-E-Bargi)، افغانستان، سابقہ ڈائریکٹر ویٹ ریسرچ انسٹی ٹیوٹ آری (AARI) فیصل آباد ڈاکٹر مخدوم حسین، ڈائریکٹر پلسز ریسرچ انسٹی ٹیوٹ آری فیصل آباد محمد رشید، چیئرمین شعبہ پلانٹ بریڈنگ اینڈ جینٹکس پروفیسر ڈاکٹر ... [illegible]

ABC CERTIFIED | باقاعدہ تصدیق شدہ اشاعت۔ ملتان، لاہور، اسلام آباد، کراچی، حیدر آباد، پشاور، سکھر اور مظفر آباد (آزاد کشمیر) سے شائع ہونے والا قومی اخبار

چیف ایڈیٹر: ضیا شاہد

Daily KHABRAIN

روزنامہ خبریں ملتان

ایڈیٹر: امتنان شاہد

پیر 9 جمادی الثانی 1439ھ 26 فروری 2018ء 14 پھاگن 2074 ب

ملتان: سپرنگ فیسٹیول کا افتتاح وفاقی وزیر سید جاوید علی شاہ، کلچرل نائٹ میں طلباء و طالبات ثقافتی رقص پیش کر رہے ہیں

محمد نواز شریف زرعی یونیورسٹی میں سپرنگ فیسٹیول کا افتتاح

پہلے روز انٹرنیشنل سیمینار آن پلسز اینڈ ویٹ فار فوڈ سیکیورٹی کا انعقاد، دالوں اور گندم کی اہمیت بتائی گئی

سیمینار میں مختلف شعبہ جات اور پاکستانی ثقافت کی خوبصورتی کو اجاگر کرنے کیلئے سٹالز بھی لگائے گئے

ملتان (عوامی رپورٹ) محمد نواز شریف زرعی یونیورسٹی میں سپرنگ فیسٹیول کا افتتاح وفاقی وزیر برائے آبی وسائل سید جاوید علی شاہ نے وائس چانسلر جامعہ پروفیسر ڈاکٹر آصف علی کے ہمراہ پودے لگا کر کیا۔ سپرنگ فیسٹیول کے موقع پر وفاقی وزیر برائے آبی وسائل سید جاوید علی شاہ نے ہائیڈروپانک یونٹ کا افتتاح بھی کیا اور ہائیڈروپانک یونٹ کا معائنہ بھی کیا۔ سپرنگ

باقی صفحہ 5 بقیہ نمبر 2

بقیہ نمبر 2 | سپرنگ فیسٹیول

فیسٹیول کے پہلے روز انٹرنیشنل سیمینار آن پلسز اینڈ ویٹ فار فوڈ سیکیورٹی کا انعقاد کیا گیا۔ ... ڈاکٹر جیکب لیگ (Jacob Lage)، ... ڈاکٹر نک برڈ (Dr. Nick Bird)، ... ڈاکٹر کرس ٹیپسل (Dr. Chris Tapsell)، ... ڈاکٹر رچرڈ ٹرےتھوان (Dr. Richard Trethowan)، ... ڈاکٹر خدائے برگی (Dr. Khuda-E-Bargi)، ... (AARI) ... [illegible]

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MULTAN: Students of Muhammad Nawaz Sharif University of Agriculture participating in tableau during cultural night.

Hydroponics unit in MNSUA inaugurated

MULTAN

Federal Minister for Water Resources, Syed Javed Ali Shah on Sunday inaugurated first hydroponic unit, established at Muhammad Nawaz Sharif University of Agriculture (MNSUA). The federal minister inspected hydroponic unit, which is the process of growing plants in sand, gravel, or liquid, with added nutrients but without soil during the seminar on the importance of food security and pulses.

Renowned international scientists namely Director Pre Breeding Dr Jacob Lage, Research Scientist Dr Nick Bird, Global Wheat Breeding Lead Dr Chris Tapsell, Prof Dr Richard from Australia, Prof Dr Khuda-E-Bargi (Uzbekistan), Director Pulses Research Institute Faisalabad Muhammad Rafique, Chairman Plant Breeding and Genetics Prof Dr Zulifqar Ali, Dean Faculty of Social Sciences, Prof Leader Pulses National Agriculture Research Centre Islamabad Dr Shahid Riaz and others delivered lectures on the importance of food.—APP

BUSINESS RECORDER

Simultaneously published from Karachi, Lahore & Islamabad

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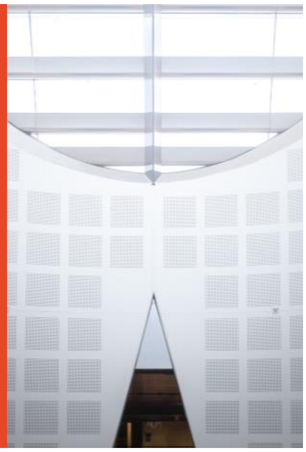
MULTAN: Students of Muhammad Nawaz Sharif University of Agriculture present a tableau during cultural night at the university.—APP photo by GM Kashif

Presentations

Genomic strategies to enhance genetic gain in practical wheat breeding.

Presented by
Professor Richard Trethowan
Plant Breeding Institute

THE UNIVERSITY OF SYDNEY



Two examples:

1. Marker assisted recurrent selection (MARS) for resistance to crown rot in wheat (*Fusarium pseudograminearum*)
   - genomic selection within populations

2. Genomic selection for heat tolerance in wheat
   - genomic selection across populations

$$\Delta G = ir\sigma_A / T$$

i = selection intensity
r = selection accuracy
σ_A = root of the additive variance
T = cycle time

Example 1. Breeding for crown rot resistance

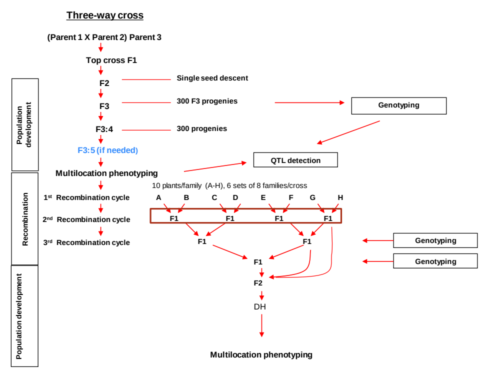
Fusarium disease of the crown and stem base

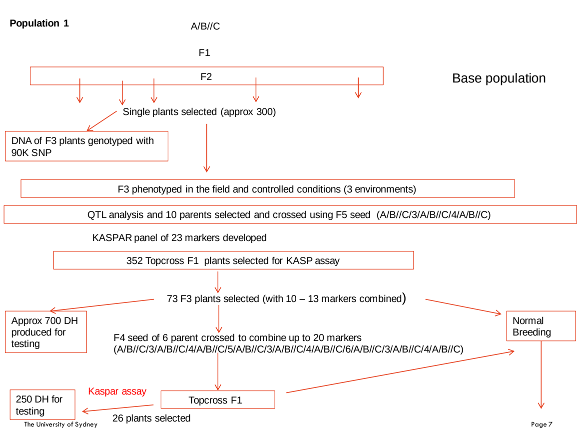
– Spreads from infected plant material
– Conservation agriculture retains stubble that acts as source
– Infection of stem bases/crown cuts off vascular tissue

Crown rot

- Very little genetic advance in 30 years
- Phenotyping is difficult with low heritability
- Sources of resistance generally have poor agronomic type
- Resistance is complex

Marker Assisted Recurrent Selection (MARS)





Crown rot – response to selection

2017 experiment with all classes	STEM BROWNING (MM) Population 1		STEM BROWING (MM) Population 2	
PARENTS	38.3	a	23.9	ac
BASE POPULATION (1st recombination)	25.0	b	32.4	b
Single recombinants (2nd recombination, 10 - 13 markers selected)	23.4	b	26.8	a
Double recombinants (3rd recombination, 18 - 20 markers selected)	18.9	c	22.7	c
CHECKS	47.6	d	41.5	e

Approx 16,000 observations/population, includes replication within and between plots
19 parents including original 3 and 16 recombinants
Approx 100 single recombinants/population
Approx 100 double recombinants/population
6 checks

Example 2. Breeding for heat tolerance

- Increasing temperatures = decrease in wheat yields (250 – 400 kg/ha for every 1° C rise in average maximum temperature)
- Heat shock (3-5 days > 35° C) significantly reduces yield if experienced at meiosis/flowering (grain seed number)
- High temperature >35° C during grain filling reduces yield (reduced grain weight)
- The inheritance of heat tolerance is complex

Phenotyping: three-tiered strategy

- **Genotypes replicated in 2-4 dates of sowing annually**
  - sub-set maintained in all years
  - best performing lines retained for the next season
  - new lines included annually
- **Heat tolerance of selected lines confirmed using in-field heat chambers**
- **Reproductive heat tolerance of selected lines confirmed in the glasshouse**

Phenotyping: three-tiered strategy

- Irrigation used to limit interactions with water stress
- Sowing dates fixed to +/- 3 days each year
- Sowing dates sown adjacent to each other
- Trial sites in Narrabri NSW, Cadoux WA and Horsham Vic.

Scaling up phenotyping

The Heat Trial TOS1 at IA WATSON

The red dots represent the drone flight planning of the site.

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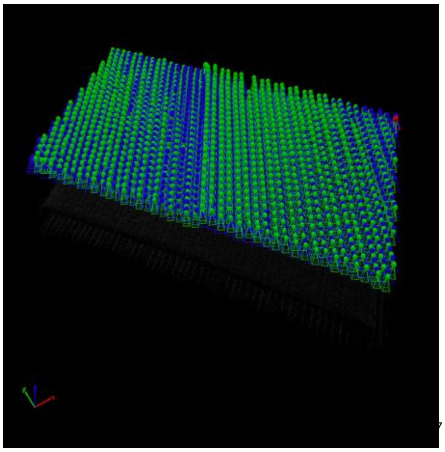

RAY CLOUD visualization, inside PIX4D software of each image. The angles represent the angle the image was captured at.

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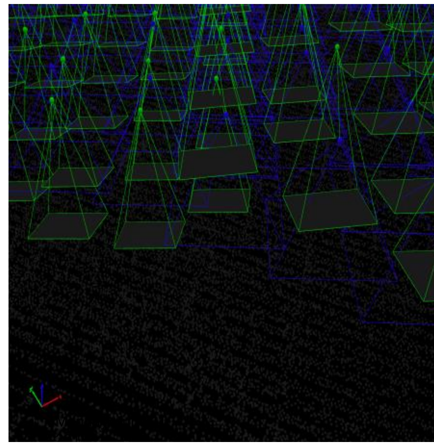

Ray Cloud: Closeup

The drone's height above the trial and its GPS location (latitude, longitude and altitude) are calculated

This information is used to make a 3D map, its also used to smooth errors associated with the movement of the aircraft.

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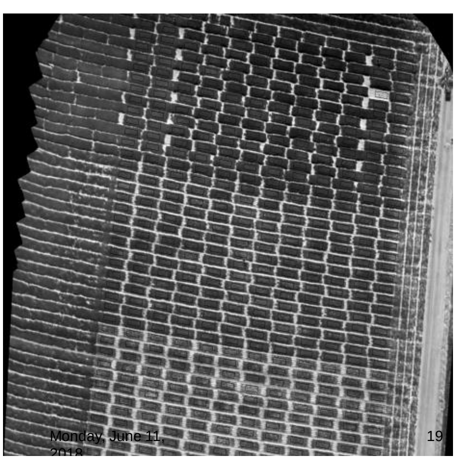

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Stage # 1 : Pre-processing

Digital numbers are "mozaiced" into a single, 3D image (x,y,z).

Grid alignment is checked at this stage.

Geographic optimization conducted using ground control points (markers with highly accurate GPS in the field).

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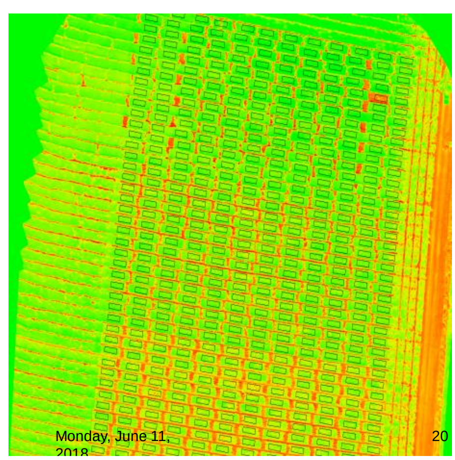

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Stage # 2 : Temperature calculation

Digital numbers are converted into actual temperatures.

1000s of pixels per plot and are extracted at an average of 1000s of 2cm x 2cm pixels

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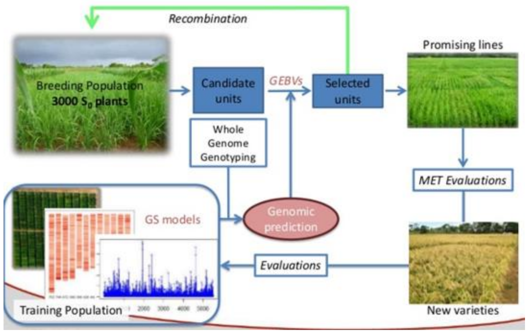
Genomic Selection



Source: David Hudson

Genomic selection for heat tolerance

Training population (3,000 diverse lines representing large populations with putative heat tolerance

↓

Extensive phenotype, 90K SNP genotype and exomes of parents

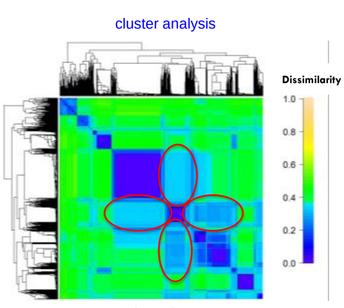
↓

Genomic estimated breeding values calculated (GEBVs)

↓

- GEBVs used to estimate performance in the next year. Validation
- Crosses made on the basis of GEBVs → F4 Progeny screened using 9K GBS and their full allelic constitution imputed from the exomes → F5 single plant selections multiplied from those lines with the highest GEBVs; → Crossing based on GEBVs

Training population structure (diversity analysis)



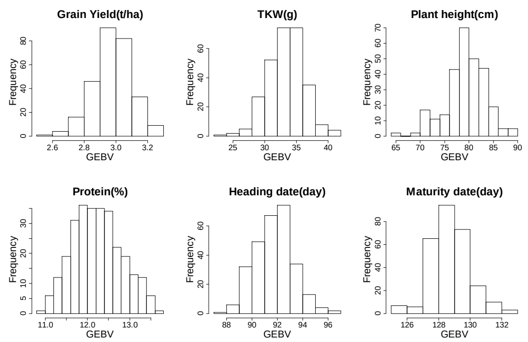
- Several families and one larger subpopulation (diagonal)
- Some connection across families through common ancestors
- Genomic prediction accuracy estimated across families

To estimate GEBVs:

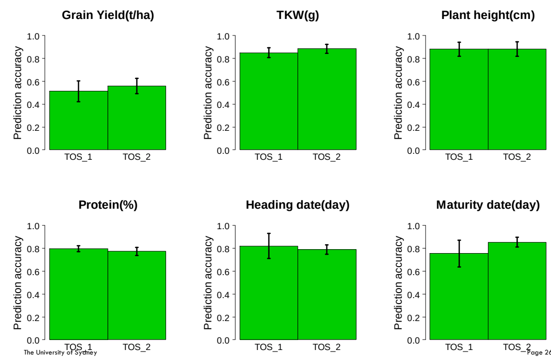
- All years of data were used and adjusted for spatial effects in each trial/environment ($y\_env = \mu + range + row + replicate + \mathbf{genotype} + error$)
- Heritabilities were calculated for each trait $h^2 = \frac{\sigma_G^2}{\sigma_G^2 + \bar{v}/2}$ (*Holland et al. 2003*)
- All years of data were then combined in a genomic BLUP model that included a GxE effect fitted as the interaction of genomics with the environment. The GEBV was then estimated as the sum of the normal mean breeding value plus the interaction term. ($BLUE_{env} = \mu + Environment + \mathbf{genotype} + error$)

↑ BLUP

GEBVs based on 2014, 2015, 2016 phenotypic data



Prediction accuracy of 2017 response



Conclusions

- Genomic strategies reduce cycle times and this potentially offsets any loss of accuracy
- Grain yield accuracy lowest and is strongly affected by genotype-by-sowing time interaction

Acknowledgements

– Mahbub Rahman (PhD student)
– Hans Daetwyler (DEDJTR)
– Sang He (DEDJTR)
– Rebecca Thistlethwaite (PhD student)
– Grains Research and Development Corporation

Plant Breeding Serves Fundamental Demands

Population growth
Food demand is expected to rise by 60 % through 2050

Harvest losses
High harvest losses due to insects (15%), weeds (13%), fungal diseases (13%), damage in storage (10%)

Climate change
Change in abiotic stress requires new variety characteristics

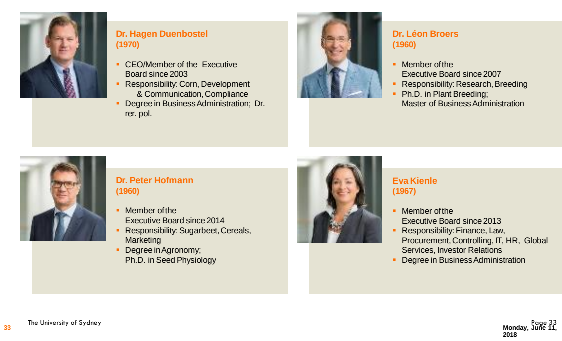
Resource efficiency
Modern varieties need less input from limited resources like fertilizer, plant protection and fresh water

Steadily increasing demand for improved varieties

Top Global Agricutural Seed Companies

Net Sales of Agricultural Crops

Sources: Companies' Annual Reports, Phillips McDougall consultants; own estimates, BASF on October 13, 2017. For Europe: estimated sales for 2016, McDougall ; own estimates
Bayer: FY 2016 (1/1 to 12/31); "Seeds" w/o flowers and vegetables.
Monsanto: FY 2015/2016 (9/1 to 8/31; 1.11 USD/EUR); „Seeds & Genomics" w/o vegetables.
Dow: FY 2016 (1/1 to 12/31; 1.11 USD/EUR); „Agriculture-Seeds".
DuPont: FY 2016 (1/1 to 12/31; 1.11 USD/EUR); „Agricultural Sciences-Seeds".
Syngenta: FY 2016 (1/1 to 12/31; 1.11 USD/EUR); „Seeds" w/o „Vegetables" and „Lawn and Garden".
KWS: FY 2016/2017 (7/1. to 6/30); incl. at equity consolidated companies.
Vilmorin: FY 2016/2017 (7/1. to 6/30); incl. at equity consolidated companies.



Dr. Hagen Duenbostel
(1970)
CEO/Member of the Executive Board since 2003
Responsibility: Corn, Development & Communication, Compliance
Degree in Business Administration; Dr. rer. pol.
Dr. Léon Broers
(1960)
Member of the Executive Board since 2007
Responsibility: Research, Breeding
Ph.D. in Plant Breeding; Master of Business Administration
Dr. Peter Hofmann
(1960)
Member of the Executive Board since 2014
Responsibility: Sugarbeet, Cereals, Marketing
Degree in Agronomy; Ph.D. in Seed Physiology
Eva Kienle
(1967)
Member of the Executive Board since 2013
Responsibility: Finance, Law, Procurement, Controlling, IT, HR, Global Services, Investor Relations
Degree in Business Administration
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The University of Sydney
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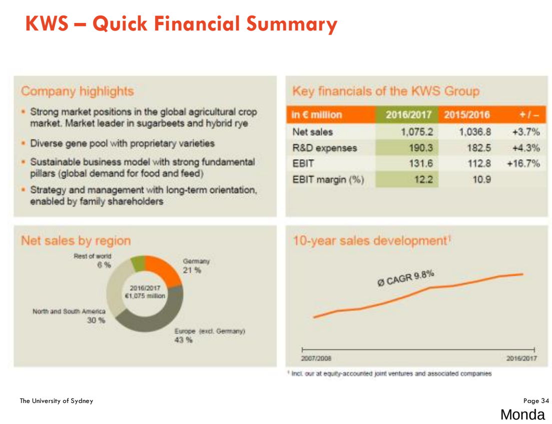

KWS – Quick Financial Summary
Company highlights
Strong market positions in the global agricultural crop market. Market leader in sugarbeets and hybrid rye
Diverse gene pool with proprietary varieties
Sustainable business model with strong fundamental pillars (global demand for food and feed)
Strategy and management with long-term orientation, enabled by family shareholders
Key financials of the KWS Group
in € million | 2016/2017 | 2015/2016 | +/–
Net sales | 1,075.2 | 1,036.8 | +3.7%
R&D expenses | 190.3 | 182.5 | +4.3%
EBIT | 131.6 | 112.8 | +16.7%
EBIT margin (%) | 12.2 | 10.9
Net sales by region
Rest of world 6 %
Germany 21 %
2016/2017 €1,075 million
North and South America 30 %
Europe (excl. Germany) 43 %
10-year sales development[1]
Ø CAGR 9.8%
2007/2008
2016/2017
[1] Incl. our at equity-accounted joint ventures and associated companies
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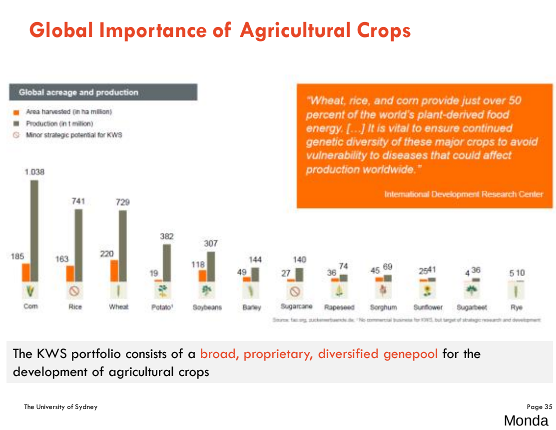

Global Importance of Agricultural Crops
Global acreage and production
Area harvested (in ha million)
Production (in t million)
Minor strategic potential for KWS
1,038
185
741
163
729
220
382
19
307
118
144
49
140
27
36
74
45
69
25
41
4
36
5
10
Corn
Rice
Wheat
Potato[1]
Soybeans
Barley
Sugarcane
Rapeseed
Sorghum
Sunflower
Sugarbeet
Rye
"Wheat, rice, and corn provide just over 50 percent of the world's plant-derived food energy. [...] It is vital to ensure continued genetic diversity of these major crops to avoid vulnerability to diseases that could affect production worldwide."
International Development Research Center
The KWS portfolio consists of a broad, proprietary, diversified genepool for the development of agricultural crops
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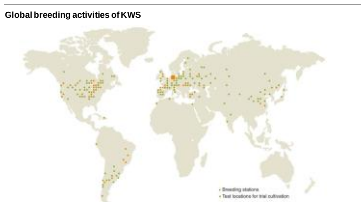
Cereals
Maize Americas
Maize rest of world
Sugar Beet
energy
R&D
3
Monday

The Key to Success: Efficient Variety Development

R&D expenditure: 17.7% of net sales

Ø yield progress: 1% to 2% per year

Phenotyping | Genomics & marker | Cell & tissue culture | GM traits
Genetic variation | Breeding competence | New breeding technologies | Bioinformatics



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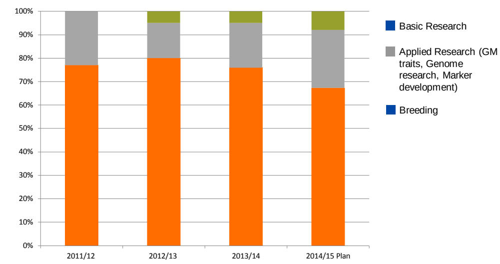
KWS R&D Budget

- Percentage of KWS research activities is continiously growing
- In 2014/15, 33% of R&D budget was used for basic and applied research



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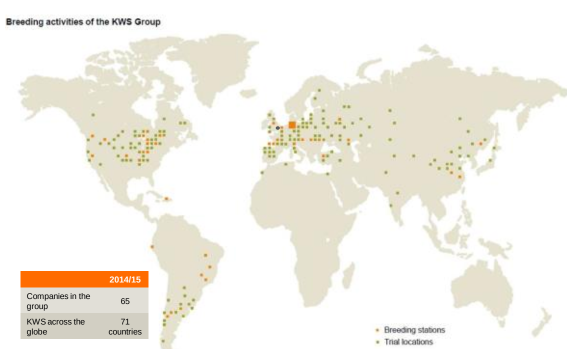
KWS Group Across the Globe

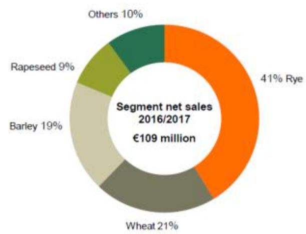


	2014/15
Companies in the group	65
KWS across the globe	71 countries

Monda

Wheat is Part of our Cereals BU Activities

Net sales breakdown
2016/2017



Breeding Wheat – Helping to Feed the World

Grain-based foods, like those produced with wheat, provide complex carbohydrates, which are the best fuel for our bodies, are low in fat, high in fibre and provide vitamins, especially the **4 key B vitamins, Thiamin, Riboflavin, Niacin, and Folic Acid, as well as iron**.

	A Host of non-food production including:
Breads	Starch Production
Pasta	Straw particle board (wood)
Breakfast cereals	Paper
Biscuits	Milk replacer
Crackers	Hair conditioners
Bagels	Adhesives on postage stamps
Cakes	Water-soluble inks
Animal Feed	Medical swabs
Wheat Distilling	Charcoal
Thickening agents	Biodegradable plastic eating utensils …
Ready-made meals….	

VERY DIVERSE QUALITY REQUIRING MARKETS

Overview of General Breeding Objectives for KWS

Yield
Sugar/energy/grain yield

Quality
Food, processing, fodder

Resistance
To diseases (e.g. fungi), to pests (e.g. insects) and abiotic stress

Nutrient use efficiency
Nitrogen, Phosphate

Agronomic properties
Hardiness, monogerm varieties, bolting resistance

Energy
Biomass/biogas yield, oil/starch/sugar yield

Specific Breeding Objectives for KWS Winter Wheat Breeding

1. Yield potential and stability

- Grain yield
- Winter hardiness
- Resistance to lodging
- Plant density
- Spike density
- Seeds per spike
- Thousand seed weight

2. Resistance to diseases

- Stalk breakage
- Take-all
- Mildew
- Yellow rust
- Wheat leaf rust
- Septoria leaf blotch
- DTR Tan spot
- Fusarium head blight
- Glume blotch
- Viral diseases

3. Quality characteristics

Milling quality
- Ash content
- Flour yield
- Grain hardness

Ethanol quality
- Starch content
- Ethanol yield

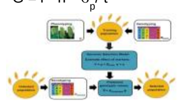
Baking quality
- Protein content
- Sedimentation value
- Falling number
- Water absorption
- Pastry quality
- Baking volume

With the exception of winter-hardiness abiotic stresses do not yet play a major role in our breeding targets

Key Breeding Drivers at KWS

- Access to excellent (proprietary) breeding material
  - Genetic resources / Genetic variability
- Focus on time to market
- Use of modern breeding technologies
  - Breeding methods (DH, GS, ..)
  - Phenotyping (Breeders eye, sensors, …)
  - Genomics and biotechnology (incl. traits)
- Efficient organization
  - Excellent employees
  - Efficient (breeding processes)
  - Integrated approach
- Innovation driven through research cooperation
- Strong link to market
  - Focus on quality
  - Appropriate variety protection

$G = i * h^2 * \sigma_p / t*$



United Kingdom
- HRW
- (HWW)
- SRW
- HRS

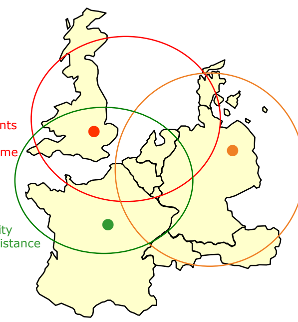
- very short and stiff plants
- yellow rust resistance
- insensitive to sowing time

Germany
- HRW
- HRS

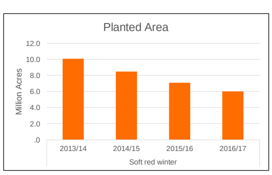
- Fusarium resistance
- winterhardiness
- quality

France
- HRW

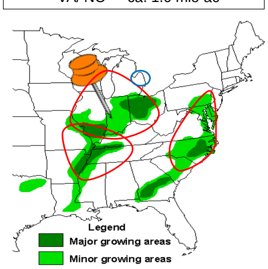
- early maturity
- leaf rust resistance
- short plants
- quality



Acreage:
D: 8.0 Mio. acre
F: 12.5 Mio. acre
UK: 4.8 Mio. acre



- Total market ca. 7 mio ac
  - UMW ca. 2.5 mio ac
  - LMW ca. 2.0 mio ac
  - VA/ NC ca. 1.0 mio ac



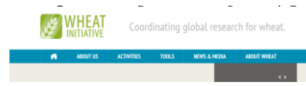
External Collaboration – KWS

- KWS has many collaborations with third party organisations
  - Universities
  - Research Institutes
  - Technology & Trait providers
  - Competitors (Pre-competitive R&D)
- A major theme for KWS has always been this '**collaborative**' approach, with **Germplasm Exchange** and the value of the '**Breeder's Exemption**' in PVR as cornerstones of how we work

External Collaboration – Wheat Focus

- KWS interacts with many in R&D activities in wheat and values working with partners who are open-minded and genuinely value collaboration
- In Wheat we provide not only funding and in-kind contributions to research projects, we also provide staff to act on advisory boards and committees for many organisations

…ders, Universities etc.
etc.)



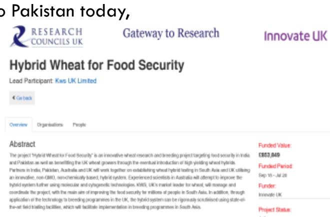
www.wheatinitiative.org

www.iwyp.org

External Collaboration – Hybrid Wheat

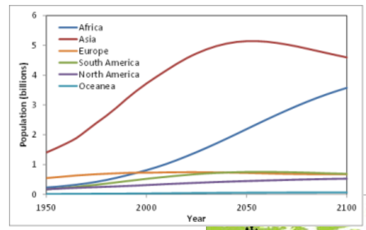
- It is as part of our collaboration activities that we have become involved in the UK Government funded project on Hybrid Wheat that brings us to Pakistan today,

which is partly funded by Department for Internatic Development [DFID]

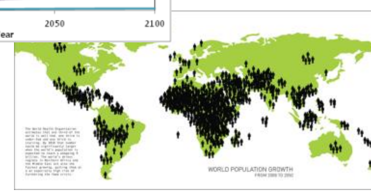


http://gtr.rcuk.ac.uk/projects?ref=101918

The world is getting hungry!



10 Billion people by 2055



Food is a key component of security

Hunger ⟶ Conflict ⟶ Migration ⟶ Conflict

Hybrid wheat for food security – a shared vision

Norman Darvey
1945-2017

"we so often talk the talk, but we also need to walk the walk; deliver outcomes that matter, addressing global food needs"

Hybrid wheat for food security – UK-funded project

- Norman Darvey had a vision and an alternative hybrid wheat system
- Global group of partners
  - Norman Darvey
  - Universities of Agriculture Faisalabad & Multan
  - University of Sydney
  - KWS
- UK funding provided by the Department for International Development
- 5-year project

Kick-off meeting, Australia Oct 2015

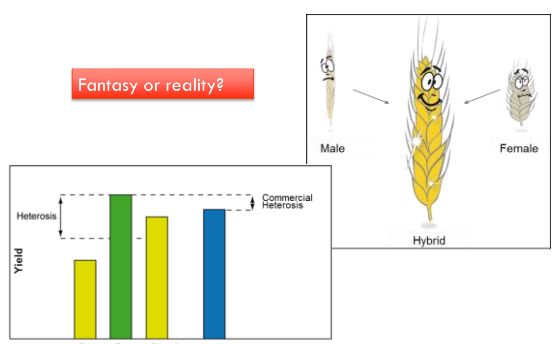
Hybrid wheat for food security – objectives

- Develop hybrids for testing in Pakistan, Australia and Europe
  - Sydney, Prof. Richard Trethowan
  - UK, Nick Bird
- Improve Norman's hybrid system
  - Cytogeneticist Peng Zhong
- Exploit heterosis in Australian and Pakistani germplasm
  - Prof. Zulfiqar Ali and Mr Ishan Karim

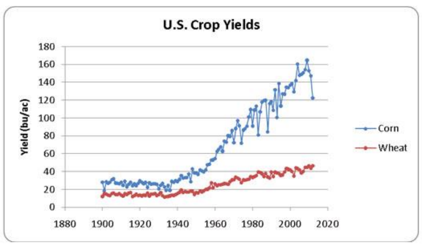
Project meeting, Australia Oct 2016

Hybrid wheat

Fantasy or reality?

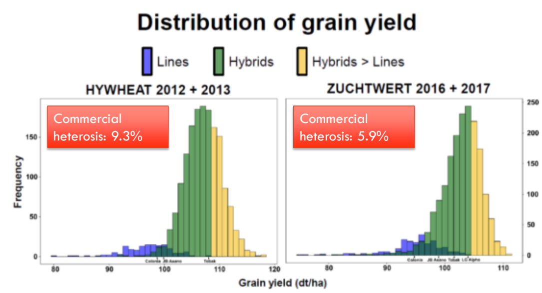


Hybrid wheat: why?



- 1909: Hybrid maize/corn "invented"
- 1924: First hybrid sold
- 1950: Most of US maize converted to hybrids

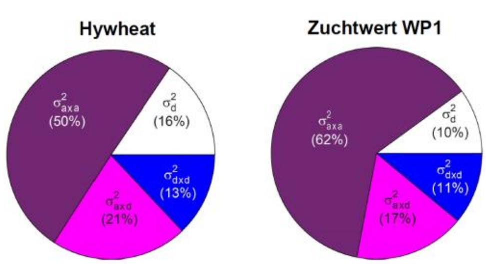
Hybrid wheat: yield gain



Best hybrid	Best line	Hybrids>lines
11.8 t/ha	10.8 t/ha	619

Best hybrid	Best line	Hybrids>lines
11.1 t/ha	10.4 t/ha	714

Hybrid wheat: where does the yield come from?



Hybrid wheat: where to find heterosis and yield stability

♀ Females; ♂ males; ★ trial sites

Hybrid wheat: many benefits

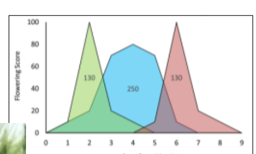
- Money!
  - Increased revenue – for all
  - Possibly to move into regions currently determined as "unprofitable"
- Increasing yield
  - High yield potential areas: ~10%
  - Marginal environments: 15-25%
- Yield stability
  - Some anecdotal evidence that hybrid wheat has increased yield stability
  - Possibly more important than yield

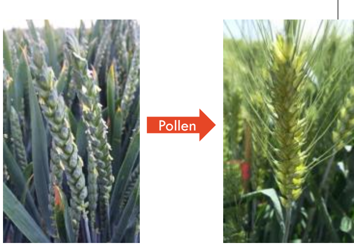
Hybrid wheat: how to make wheat sterile?

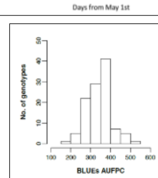
- Chemical hybridisation agents (CHA)
- Genetic engineered nuclear-encoded systems
- Biological, native trait, systems
  - Cytoplasmic male sterility (CMS)
    - *Triticum timopheevii*
    - *Aegilops kotschyi*
  - Nuclear male sterility (NMS)
    - *ms1*
    - Environment sensitive genetic male sterility

Hybrid wheat: floral biology is a key trait

- Self-pollinating -> cross-pollinating
  - Anther extrusion
  - Pollen production
  - Flowering duration







The beginning

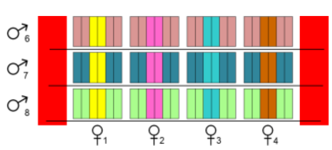
It all started in Norman's back garden

Scaling up

The work moved to University of Sydney's breeding station in Narrabri

Mr Ishan Karim from University of Agriculture Faisalabad moved there for one year

First hybrids produced

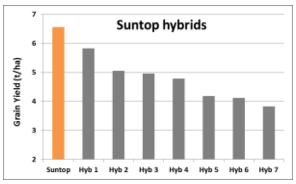


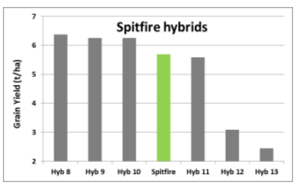
UK

Australia

Hybrids tested – In Australia

Decent results from first year





Hybrids tested – In Pakistan

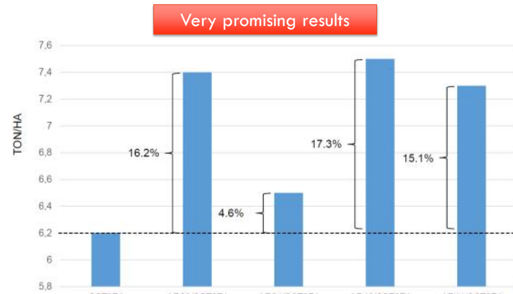
Hybrids tested – In South Africa

SENSAKO
Beproefde Genetika • Proven Genetics

AR19/SST374

Hybrids tested – In South Africa

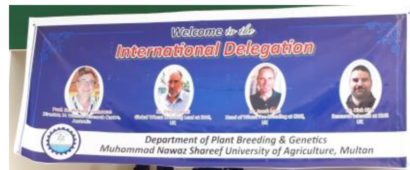
Very promising results



SENSAKO
Beproefde Genetika • Proven Genetics

Hybrids tested – In UK and Germany

Project meetings – In Pakistan



Project meetings – In Australia

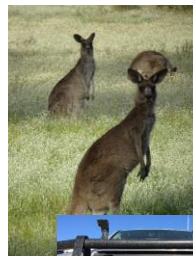
Even made a visit to India

Indian Agricultural Research Institute (IARI) is a collaborator on project and will test hybrids in 2019

Had some failures

"If you never fail, then you are not trying hard enough"

…and some fun



and coffees

The second half of the project

- Pakistan
  - Multi-location yield trials with Pakistani hybrids
  - Quality test of hybrids
  - Production of new hybrids and initiate hybrid breeding
- Australia
  - Multi-location yield trials
  - Further improvement of hybrid system
- UK
  - Multi-location yield trials with hybrids based on KWS parents
- India
  - Multi-location yield trials with hybrids based on Indian parents

Keep working together for food security

THANK YOU!

"We should all feel blessed by the privilege of working together in peaceful environments so that we can contribute to food production in the poor and hungry nations on earth"

Molecular marker resources

- KWS' genotyping facility is based in Einbeck, Germany and handles samples from all KWS crops.
- The genotyping facility process approximately:
  - 55,000 wheat DNA extractions
  - 25,000 wheat samples run on arrays, predominantly for genomic selection
  - 50,000 Wheat KASP datapoints for MAS and research projects.
- KWS access all public resources for wheat genotyping
  - 9K Wheat Array (Illumina)
  - Wheat iSelect Array (Wang et al.)
  - Wheat 820K Array (Affymetrix)
  - 35K Wheat breeders array (Affymetrix)
  - 35K breedwheat Array (Affymetrix)

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Trait mapping to marker deployment

- For a specific loci the long term use of arrays is not cost effective.
- The faster the trait can be mapped and tracked using KASP markers the better.
- KWS Wheat pre-breeding in conjunction with the Biotechnology team employ a traditional approach to QTL mapping and gene cloning.
- Segregating populations are assessed phenotypically and lines are genotyped.
- Traditional QTL mapping conducted to determine region of interest.
- Depending on size of region further recombinant mapping maybe warranted.
- Recombinants in the QTL region are identified from the population and only these lines are phenotyped.
- Phenotypes and further genotyping of critical recombinants determine gene position.
- If sufficiently close enough, cloning by sequencing and / or candidate gene testing identifies the gene of interest.

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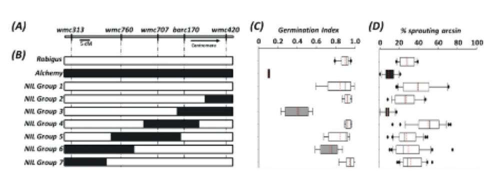
Trait mapping to marker deployment

- Robigus x Alchemy population identified as having differential phenotypes in pre-harvest sprouting
- Traditional QTL mapping was done on a DH population identifying chromosome 4A
- NILs across the identified region were made for QTL validation



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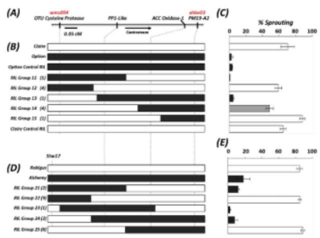
Trait mapping to marker deployment

Recombinants in the region identified from 2 populations.
Further genotyping and phenotyping narrowed region allowing candidate genes to be identified



TaMKK-3 identified as causative gene via functional gene analysis

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WAGTAIL

- Wheat Association Genetics for Trait Analysis and Improved Lineages.
- BBSRC funded project with NIAB and multiple commercial companies.
- Project started 2011 and ended in 2016.
- Project aims
  - Genetically fingerprint 480 predominantly UK winter wheat varieties.
  - Phenotype for the 5 major fungal disease in wheat.
  - Use genetics and disease scores to pinpoint sources of genetic

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Yellow rust population changes

- 2013 saw massive shift in the UK yellow rust population.
- New race named the warrior race.
- In the following years yet more changes have occurred.
- Many efforts in trying to explain what has happened and managing the current situation are on going.

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Results – Yellow Rust

- 12 resistance loci for yellow rust identified and validated post warrior race.
- No current variety has all 12 resistance loci.
- To date no information on which gene(s) is most effective.

- How are we using this information?
  - Number of resistance loci per variety information passed to breeders.
  - Maximum Yellow rust genetic performance per cross can be predicted.

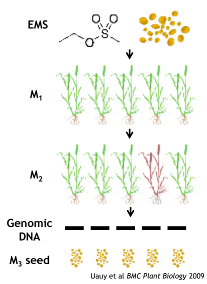
Max yellow rust genetic performance

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
	Parent YR loci	5	5	6	8	2	4	5	2	5	6	2	4	5	5	4	6	4	7	6	3	8	8	4	5	2	5	7	5
1	5	X	10	9	12	7	7	7	7	9	9	7	7	7	7	6	7	7	7	10	X	10	10	8	10	7	7	9	9
2	5	10	X	7	8	X	9	10	7	8	9	X	7	8	8	9	9	7	12	6	8	8	8	6	X	X	8	10	8
3	6	9	7	X	10	7	8	9	8	10	9	7	7	8	8	8	9	9	11	8	7	8	8	7	7	7	8	10	10
4	8	12	X	10	X	X	10	10	X	X	10	X	10	10	10	10	12	10	12	X	10	10	10	X	X	X	10	10	X
5	2	7	5	7	8	X	6	7	4	5	6	X	4	5	5	6	6	4	9	6	5	8	8	6	5	X	5	7	5
6	4	7	9	8	10	6	X	5	X	7	6	6	6	7	7	5	8	8	7	10	5	10	10	8	9	6	7	7	7
7	5	7	10	9	10	7	X	X	X	7	7	7	7	7	7	X	9	9	7	10	X	10	10	8	10	7	7	7	7
8	2	7	7	8	8	4	4	5	X	5	6	4	6	7	7	5	8	6	7	8	5	10	10	6	7	4	7	7	5
9	5	9	8	10	8	X	7	7	X	X	7	X	7	7	7	7	9	7	9	8	7	10	10	8	8	X	7	7	X
10	6	9	9	9	10	X	X	7	X	7	X	X	X	7	7	7	8	8	9	10	7	10	10	10	9	X	7	7	7
11	2	7	5	7	8	X	6	7	4	5	6	X	4	5	5	6	6	4	9	6	5	8	8	6	5	X	5	7	5
12	4	7	7	7	10	X	6	7	6	7	6	X	X	5	5	6	6	6	9	8	5	8	8	8	7	X	5	7	7
13	5	7	8	8	10	X	7	7	7	7	7	X	X	X	X	6	7	7	9	8	X	8	8	8	8	X	X	7	7
14	5	7	8	8	10	X	7	7	7	7	7	X	X	X	X	6	7	7	9	8	X	8	8	8	8	X	X	7	7
15	4	6	9	8	10	6	5	5	5	7	7	6	6	6	6	X	8	8	7	9	X	9	9	7	9	6	6	7	7
16	6	7	9	9	12	X	8	9	8	9	8	X	X	7	7	8	X	X	9	10	7	10	10	10	9	X	7	9	9
17	4	7	7	9	10	X	8	9	6	7	8	X	6	7	7	8	6	X	9	8	7	10	10	8	7	X	7	9	7
18	7	X	12	11	12	9	X	X	X	9	9	9	9	9	9	X	9	9	X	12	X	12	12	10	12	9	9	9	9
19	6	10	X	8	8	X	10	10	8	8	10	X	8	8	8	9	10	8	12	X	8	8	8	X	X	X	8	10	8
20	3	5	8	7	10	5	5	5	5	7	7	5	5	5	5	4	7	7	7	8	X	8	8	6	8	5	5	7	7
21	8	10	X	X	10	X	10	10	10	10	10	X	X	X	X	9	10	10	12	X	X	X	X	X	X	X	X	10	10
22	8	10	X	X	10	X	10	10	10	10	10	X	X	X	X	9	10	10	12	X	X	X	X	X	X	X	X	10	10
23	4	8	6	7	8	6	8	8	6	8	10	6	8	8	8	7	10	8	10	6	6	8	8	X	6	6	8	10	8
24	5	10	X	7	8	X	9	10	7	8	9	X	7	8	8	9	9	7	12	6	8	8	8	6	X	X	8	10	8
25	2	7	5	7	8	X	6	7	4	5	6	X	4	5	5	6	6	4	9	6	5	8	8	6	5	X	5	7	5
26	5	7	8	8	10	X	7	7	7	7	7	X	X	X	X	6	7	7	9	8	X	8	8	8	8	X	X	7	7
27	7	9	10	10	10	X	X	X	X	X	X	X	X	X	X	X	9	9	9	10	X	10	10	10	10	X	X	X	X
28	5	9	8	10	8	X	7	7	X	X	7	X	7	7	7	7	9	7	9	8	7	10	10	8	8	X	7	7	X

Maximising yellow rust genetic resistance

- This new genetic data is being used now.
- Profiling current lines in National testing.
- Designing the next set of crosses to be made as part of the breeding process.
- Contributing to decisions on acceleration of lines through the breeding process.
- All this information whilst being used currently in in-bred lines can and will form part of the breeding strategies for hybrid wheat.

Introducing novel allelic variation – The pipeline



- EMS mutagenesis introduces base pair substitutions leading to new alleles
- Exome capture and sequencing of M2 DNA identifies these base changes and can predict the effect on gene.
- 1200 mutated lines have been selfed to M4 families.
- The population has 6.4 million mutations in its exome.
- 70,000 predicted genes will have non-functional alleles
- Cadenza mutants being utilised in wheat pre-breeding program and multiple projects involving KWS

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Introducing novel allelic variation – The pipeline

- Using Blast you can search for your gene(s) of interest.
- 10,000,000 mutant alleles across both tetraploid and hexaploid populations.
- Identify the most appropriate mutation (premature stop, splice site variant, etc).

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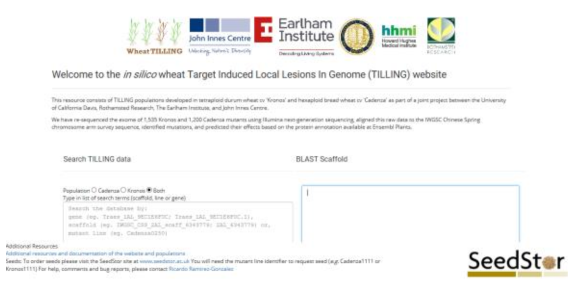
Introducing novel allelic variation – The pipeline

WWW.Wheat-tilling.com



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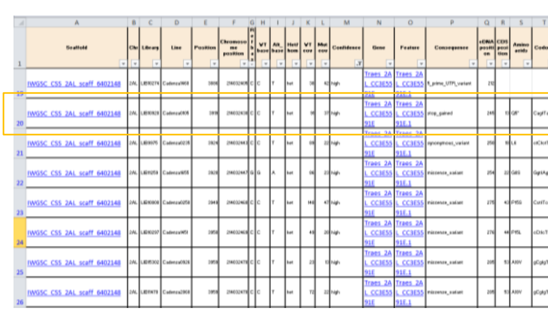
Introducing allelic variation – The pipeline



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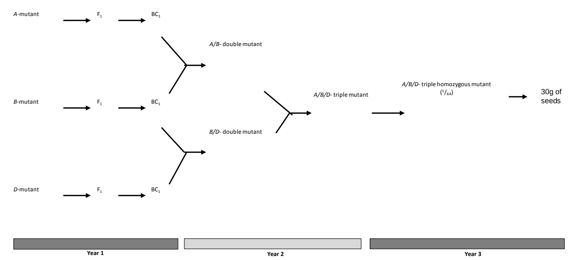
Introducing allelic variation – The pipeline

- Using Blast you can search for your gene(s) of interest.
- 10,000,000 mutant alleles across both tetraploid and hexaploid populations.
- Identify the most appropriate mutation (premature stop, splice site variant, etc).
- 100,000 mutations will cause truncations (premature stop, splice site variant).
- Order these mutants (£250 each with FTO, £25 research only).
- Design KASP marker to track mutation using Polymarker (www.polymarker.tgac.ac.uk).
- Many targets need to be in homozygous null state in all 3 genomes for maximum (or sometimes any) effect to be seen.
- KWS have approximately 20 mutants in back crossing program at any one time.

Backcrossing scheme to KWS Variety



Summary

- KWS has a large genotyping facility which processes in excess of half a million samples a year.
- Approximately 10% of these samples are for the global wheat programs,
- Cost effective use of genotyping is essential to breeding programs.
- KWS are heavily involved in trait mapping and efficient usage of these traits in breeding programs.
- The UK wheat community collaborates closely in many projects to achieve more than any individual can.
- Effective utilisation of outputs from projects is essential to ensure progress.
- Public resources like the tilling libraries are opening up new, faster methods of genetic gain for public and commercial organisations.

STATUS OF WHEAT , CHALLENGES AND PROSPECTS OF WHEAT CULTIVATION IN PUNJAB/PAKISTAN

Dr. Makhdoom Hussain
makhdoomhussain@yahoo.com

AREA, PRODUCTION & YIELD OF WHEAT IN TOP 10 WHEAT PRODUCING COUNTRIES (2016-17)

Area (000) ha	Production (000) Tons	Yield Tons/ha
India (30600)	China (130000)	China (5.37)
Russia (28600)	India (98380)	Ukraine (4.02)
China (24200)	Russia (82000)	India (3.22)
USA (15211)	USA (47371)	USA (3.11)
Australia (12500)	Canada (27000)	Russia(3.06)
Pakistan (9050)	Ukraine (26500)	**Canada (3.00)**
Canada (9000)	**Pakistan (26200)**	Pakistan (2.90)
Turkey (7800)	Australia (21500)	Turkey (2.69)
Iran (6800)	Turkey (21000)	Iran (2.21)
Ukraine (6600)	Iran (15000)	Australia (1.72)

Global Wheat Scenario

- **Global Production** **742 mt**
- **Pak Production** **> 26 mt**
- **Punjab Production** **> 20 mt**
- **Pakistan** **7th Wheat Producer**

WHEAT YIELD INCREASE OVER THE YEARS IN PUNJAB - PAKISTAN

Year	Yield Kg/ha (Punjab)	Yield Kg/ha (Pakistan)
2014-15	2763	2726
2015-16	2817(2%)	2753(1%)
2016-17	3014(9%)	2900(6%)

Global wheat production during the current year is 742 million tons as compared to last year 754 million tons (- 1.62%)

WHEAT: PROJECTED REQUIREMENTS PAKISTAN

Year	Requirement (m. tones)	Av. Yield (tones/ha)
2020	28.8	3.2
2025	31.4	3.5
2030	34.3	3.8

It includes human consumption (120 Kg / person with population growth of 1.8% per annum), feed and seed (10% of production), food security reserve (1.0 million tones)

HISTORY OF GREEN REVOLUTION

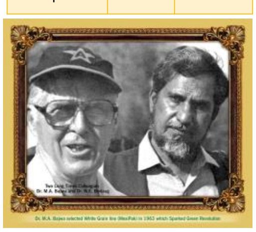
– Pakistan 1965-66

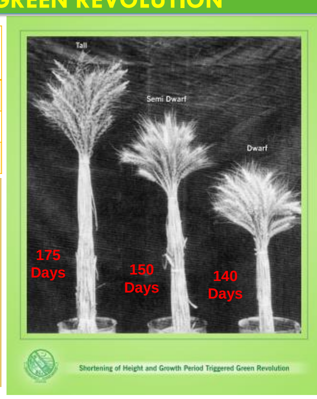
– Mexico 1966-67 India 1967-68

– It was a young Pakistani researcher (Dr. Manzoor Ahmad Bajwa) who, in 1961, selected the cross that later became known as MexiPak; a high yielding, white grain wheat that became one of the mega-varieties that launched the Green Revolution in the world.

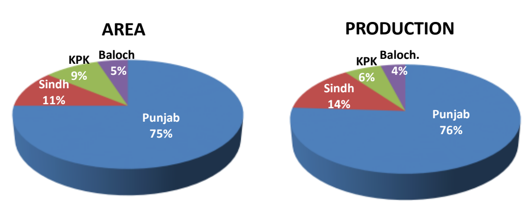
SHORTENING OF HEIGHT AND GROWTH PERIOD TRIGGERED GREEN REVOLUTION

Name of variety	Plant Height	Maturity Days
C-591	150	175
Maxi Pak-65	115	150
Shafaq-06	80	140

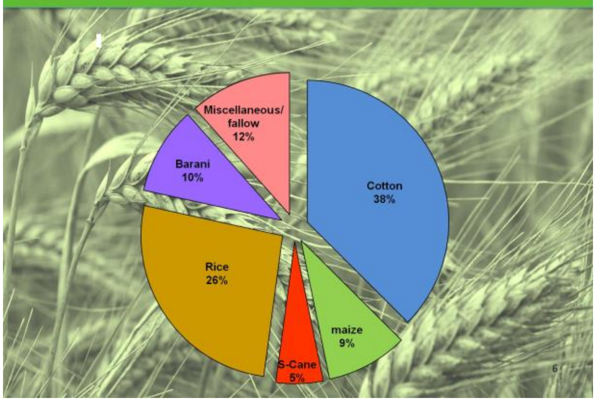




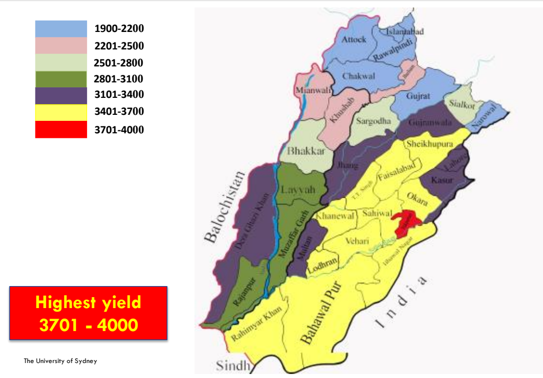
Provincial Share in Area and Production of Wheat



WHEAT AREA IN DIFFERENT REGIONS OF PUNJAB



YIELD TREND OF WHEAT IN PUNJAB PROVINCE 2016-17 (kg/hectare)



ISSUES/ CHALLENGES

- Climate change scenario
  - Drought (especially erratic rains in barani tract)
  - rains, winds and hail storms at the time of harvesting
  - Frost stress
  - Terminal Heat Stress (Global warming)
  - 0.5°C increase in temperature reduce wheat yield by 0.45 Tons/ha.
- Late wheat Planting
  - 17-20 kg/acre/day losses or 1% loss per day
  - Change in planting time
- Diseases especially rusts Up-to 70% loss
  - Change in appearance of rusts. (Lr - Yr - Lr)
  - Bunts
  - Wheat Blast Apparently not found in Pakistan
- Soil health, fertilizer (cost, availability & imbalanced use)
  - Imbalanced Fertilizer = 30-55%
  - Low organic matter = < 1%
- Insect/pest especially Aphid Up-to 40% loss
- Weeds
  - Up-to 40% losses , resistance in weeds against weedicides
- Seed 20 – 25 % replacement annually
- Small holdings (80%) and Urbanization

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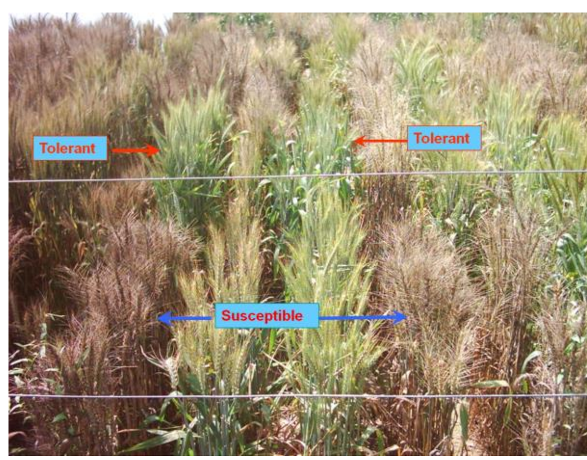
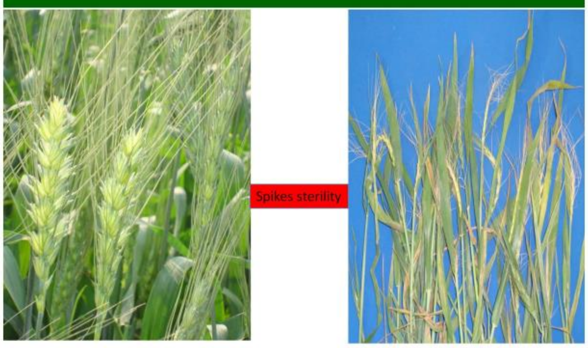


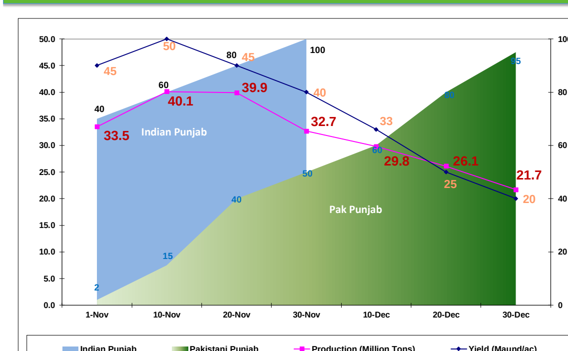
Frost stress



Frost stress

Frost (Intensity & effect)

SOWING DATE PATTERN AND ITS IMPACT ON WHEAT PRODUCTION IN PUNJAB



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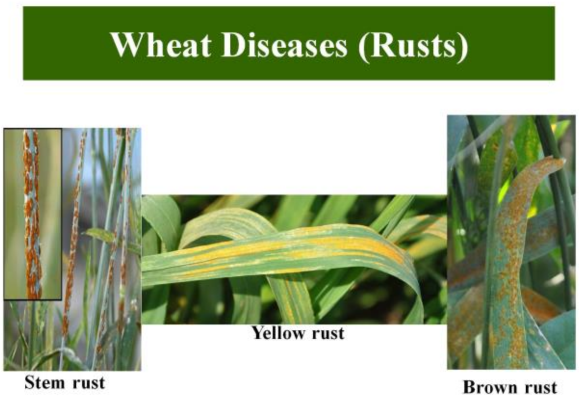
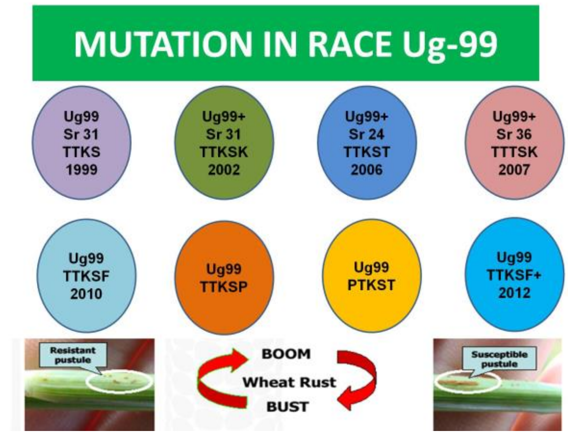
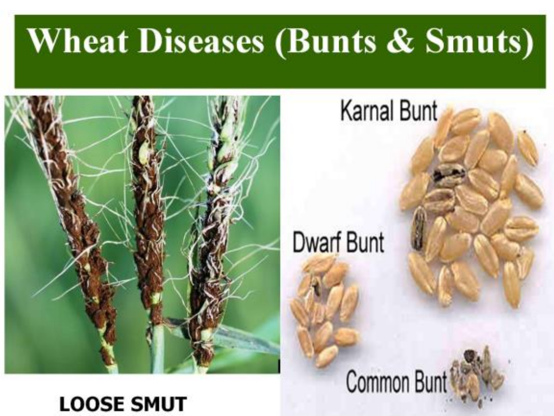
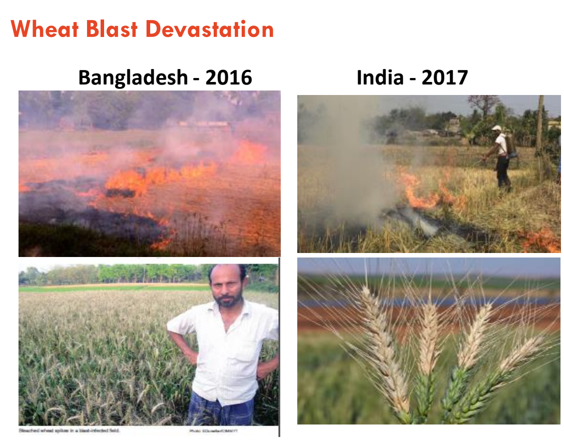

Wheat Diseases (Rusts)
Yellow rust
Stem rust
Brown rust

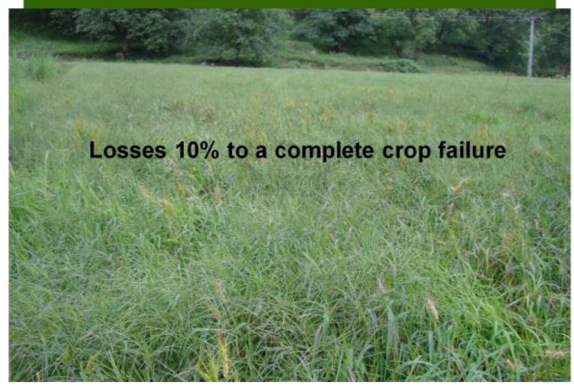

MUTATION IN RACE Ug-99
Ug99 Sr 31 TTKS 1999
Ug99+ Sr 31 TTKSK 2002
Ug99+ Sr 24 TTKST 2006
Ug99+ Sr 36 TTTSK 2007
Ug99 TTKSF 2010
Ug99 TTKSP
Ug99 PTKST
Ug99 TTKSF+ 2012
Resistant pustule
BOOM
Wheat Rust
BUST
Susceptible pustule


Wheat Diseases (Bunts & Smuts)
Karnal Bunt
Dwarf Bunt
Common Bunt
LOOSE SMUT


Wheat Blast Devastation
Bangladesh - 2016
India - 2017

Aphid (Coccinella spp)

Weed problem



Problem Soils

Strategies to overcome effects of climate change

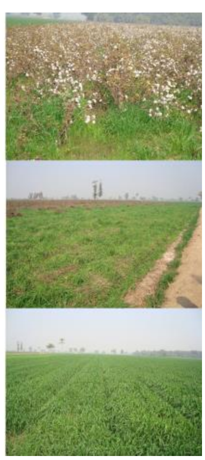
- Breeding strategies:
  - Breeding of heat, drought and frost tolerant varieties
  - Short duration wheat varieties
  - Physiological breeding using modern gadgets
    - Canopy temperature
    - Flag leaf stomatal conductance
    - Photosynthetic rate
    - Greenness
    - Electrolyte leakage (Cell membrane thermo-stability)
  - Use of molecular tools for efficient selection

Screening Against Heat

Strategies to overcome effects of climate change

- Management strategies
  - Change in cropping pattern
    - Include Pulses in rotation e.g. Wheat-Mung-Rice, etc.
    - Resource conservation.
    - Wheat planting in standing cotton.
    - Bed sowing to save water and to reduce lodging.
    - Zero till and direct seeded rice.
    - Sowing of wheat at proper time.
    - Application of Zinc to improve enzymatic reaction in plants.

Wheat In Standing Cotton



- No land preparation
- Cost saving
- Timely crop planting
- Builds soil organic matter
- Reduces compaction
- Improves yield
- Environment friendly

Zero Till Planting

- No land preparation
- Cost saving
- Timely crop planting
- Builds soil organic matter
- Reduces compaction
- Improves yield
- Environment friendly

Research Institutes Working on Wheat

- WRI, Faisalabad
- RARI, Bahawalpur
- BARI, Chakwal
- AZRI, Bhakkar
- Biotechnology, Faisalabad

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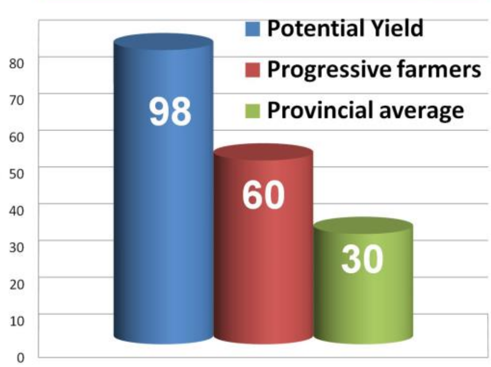
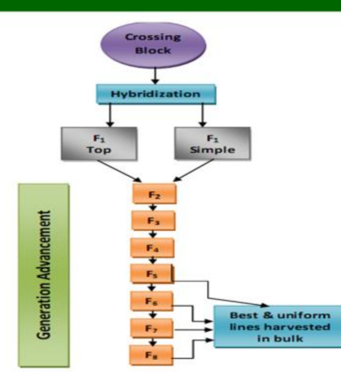
Research Disciplines

- Breeding
- Pathology
- Entomology
- Agronomy
- Quality
- Biotechnology
- Seed production
- Shuttle Breeding:
  - Kenya
  - Kaghan
  - Murree

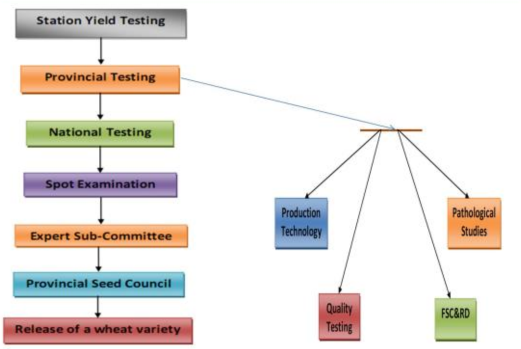
YIELD GAP (Maunds/ acre)



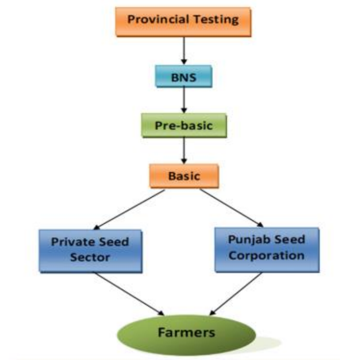
VARIETY DEVELOPMENT PROCEDURE



YIELD TESTING AND VARIETAL APPROVAL



SEED SYSTEM



Need for Quality Evaluation

National and International compulsions

Wheat variety development program

- Quick and reliable quality assessment
- Evolution of wheat varieties with good quality traits
- Resistant varieties
- Nutrient rich varieties

Wheat and milling tests

- **Moisture Content**
- **Ash Content**
- **Protein Content**
- **Thousand Kernel Weight**
- **Starch**
- **Gluten**
- **Sedimentation**
- **Single Kernel Characterization System (SKCS**

Flour and dough tests

- **Falling Number**
- **Flour Color Analysis**
- **Farinograph**
- **Extensograph**
- **Glutomatic**
- **Fermentograph**

Capacity Building

Trainings imparted

- **Training on Wheat Breeding/ Production Technology to:**
  - Master trainers of Extension Wing
  - Scientists from other provinces
  - Farmers
- **Rust Identification to:**
  - Extension wing of Agriculture
  - Pest Warning and quality control
- **Guidance/practical training to University students:**
  - Internship programme
  - Post-graduate & Ph.D. research

Trainings conducted by Wheat Research Institute, Faisalabad

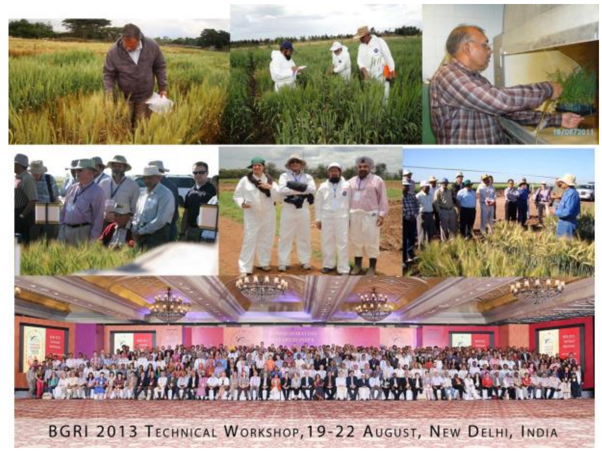
Capacity Building

Foreign Trainings Received

– Dr. Javed Ahmad	Kenya, USA, Mexico
– Dr. G.M. Subhani	Ethiopia, UK, Turkey
– Faqir Muhammad	Nepal
– Dr. M. Abrar	Singapore
– Anjam Javed	Singapore
– Nadeem Ahmad	USA, Mexico, Kenya
– Muhammad Hussain	USA
– Faqir Muhammad	Mexico
– Dr. M. Akbar	Mexico
– Javed Anwar	Syria
– Sabina Asghar	Nepal, USA, Mexico
– Muhammad Zulkiffal	Mexico
– Huma Safdar	USA
– Rabia Sultan	USA
– Dr. Makhdoom Hussain	USA, Russia, Nepal, Mexico, Syria, Turkey, Australia, Kenya

Visit of international scientists

Dr Norman E. Borlaug	CIMMYT	Dr Micheal Jones	Australia
Dr Mathew Reynolds	CIMMYT	Dr Hans Braun	CIMMYT
Dr Rick Ward	CIMMYT	Dr David Marshall	CIMMYT
Dr Osman Abdallah	ICARDA	Dr Xian Ming	USDA, USA
Dr Michael Baum	ICARDA	Dr K.D. Joshi	CIMMYT
Dr Zewdie Bishaw	ICARDA	Dr Abdul Rahman Bashir	CIMMYT
Dr Kumarse Nazari	ICARDA	Dr Upali Samarajeewa	Sri Linka
Dr Akram Khan	Australia	Dr L. G. Wigemark	EU
Dr Javed Iqbal	USA	Dr Anne Mackanze	FAO
Dr Alistair Pask	CIMMYT	Dr I. W. Borne	USDA
		Dr Kulvender Singh	UC DAVIS



Training of WRI Staff by Foreign scientists

Farmer interaction

Farmer's days arranged by WRI at farmers fields

Farmer's days arranged by WRI

Farmer Days

Seed Distribution

Demonstration on farmers fields

100th Birthday celebrations of Dr. Norman Borlaug

100th Birthday celebrations of Dr. Norman Borlaug

Achievements of AARI in 2016-17

Six wheat varieties released

- Ujala-16 Johar-16 Gold-16
- Ihsan-16 Fatehjang-16 Anaj-17

Two Barley Varieties

- Jau-17 Sultan-17

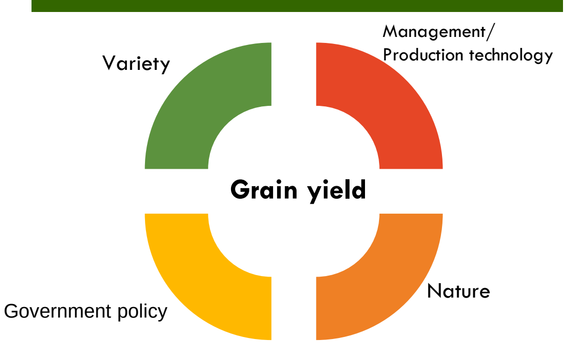
- Advance line (V-12066) found resistant to all 3 rusts on the basis of two year studies by CDRI, Islamabad.
- Advance line (V-14154) performed excellent on Pakistan basis with yield of 4329 kg/ha and was on top position with yield of 4266 kg/ha on Punjab basis in NUWYT 2016-17.
- Wheat line (V-14124) attained top position in PUWYT 2016-17 producing 4360 kg/ha.

Achievements of AARI in 2016-17

Six w Cereal Technology Laboratory got accredited " ISO – 17025 "

1st Lab in the history of Research Wing.

Yield Contributors



Record Production in Punjab (2016-17)

Production > 20 mt

Due to

- Availabilities of good varieties

- Good Management Practices

(Balance use of fertilizer, availability of irrigation water, weeds control)

- Better Government Policies

(Subsidized inputs, provision of certified seed, loan & machinery)

- Favorable weather conditions

(less fogy days, cool nights, favorable temp. at grain fill stage, less lodging & rust attack)

- It was all due to the blessing of Almighty Allah

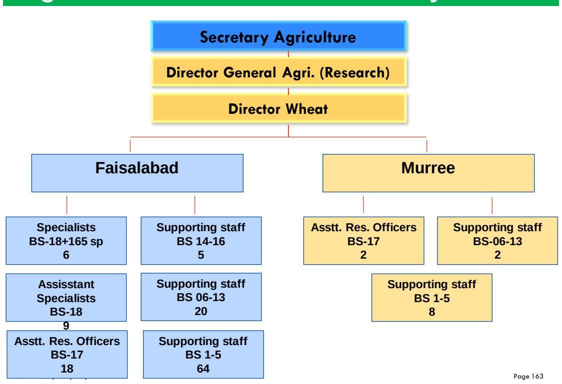
Economic worth of wheat over the year in Punjab

Particular	Production (000) Tons
2015-16	19527
2016-17	20466
Increase over the year	939
Economic worth (Billion Rs.)	
• Wheat Grains	30.52
• Wheat Bhoosa	7.04
Total worth:	37.56

VISION FOR RESEARCH

- Breeding for Nutrition Enhancement in wheat (Genetic, bio-fortification & value addition) to overcome malnutrition problems
- Development of zone specific wheat varieties suitable for different cropping systems under changed climate scenario (Special focus in rice zone).
- Development of stress resilient wheat varieties (Drought, Terminal Heat Stress, Frost, Salinity and Diseases)
- Development of nutrient efficient varieties and Integrated plant nutrient Management system

Organizational structure/ hierarchy

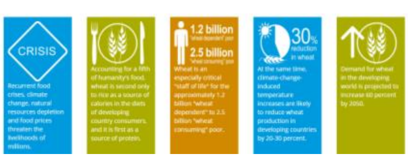


Scientists of WRI, Faisalabad

Architecting Self-Irrigating Wheat Through Fog Capturing

Zulfiqar Ali PhD
Professor and Chairman
Department of Plant Breeding and Genetics

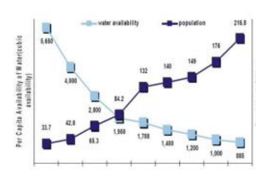
Rationale



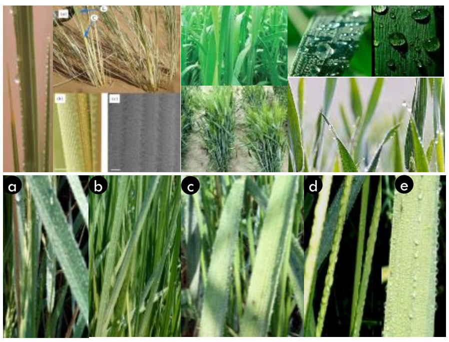
Abrupt climatic changes - drought spells and heat waves

More frequent and intense in the coming decades

Rationale



Pakistan is 7th most vulnerable country



Contact angle

θ a= 98
θ r = 56
θ a-r = 42

α > 13.7

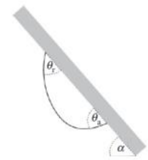
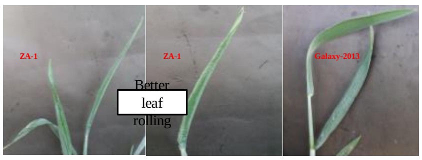


Figure 8. Droplet hanging down from a plane which is inclined against the horizontal axis by an angle α. θ_r and θ_a denote the receding and advancing contact angle, respectively.

Objectives and outcomes

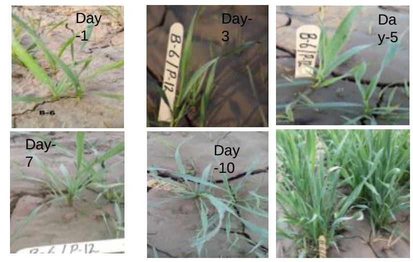
Development of drought and heat tolerant wheat germplasm

- An assembly of novel leaf surface structural traits
  - erect leaves with minimum leaf-to-stem angle
  - leaf rolled longitudinally
  - leaves having prickle hairs
  - grooves running parallel to the long axis of the plan
- Information on morphological and cytological bases of drought and heat tolerance
- Drought and heat tolerant wheat germplasm



Genotype	Prickle Hairs	Leaf Rolling	Leaf Angle	Groove Type
ZA-1	8	1	1	1
Galaxy-13	7	2	2	2

Genotype	Moisture %
ZA-1	11.12
Galaxy-13	8.04



Genotype	Moisture	
	Root Zone	Vicinity
B-6	7.2	4.1

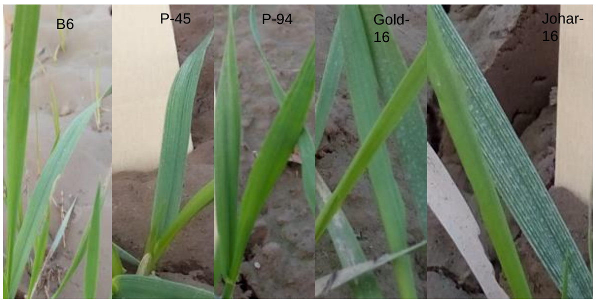
Genotype	Prickle Hairs	Leaf Rolling	Leaf Angle	Groove Type
B-6	1	4	1	4

Genotype	Moisture	
	Root Zone	Vicinity
A-1	5.0	3.4

Genotype	Prickle Hairs	Leaf Rolling	Leaf Angle	Groove Type
A-1	8	2	2	2

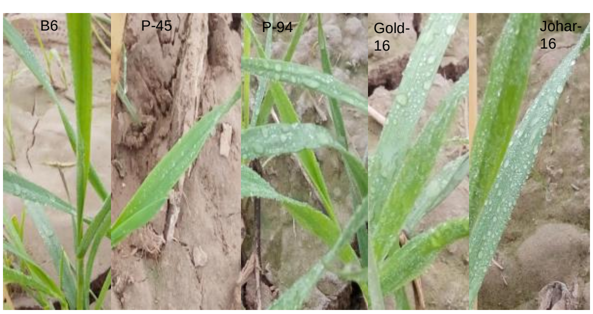
Genotype	Moisture	
	Root Zone	Vicinity
Chakwal-86	5.6	4.5

Genotype	Prickle Hairs	Leaf Rolling	Leaf Angle	Groove Type
Chakwal-86	7	1	1	1



18-01-18

23-01-18



28-01-18

 # 28 PED=N28 PED:AR-5 ex HP80a × UJALA-16

• Grain weight = 834.52g

Acknowledgement

US-PCAS-AFS

PARB

UC Davis

Faculty and students

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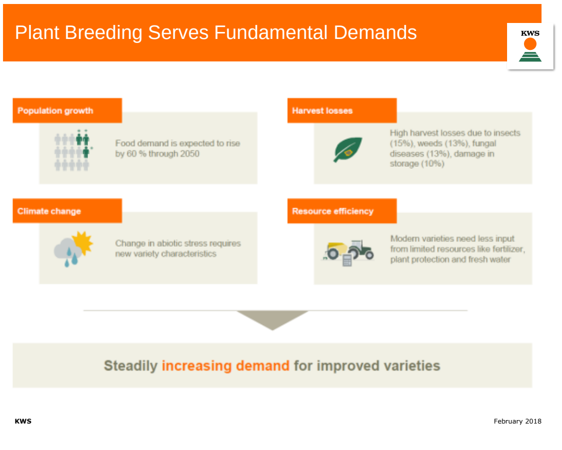
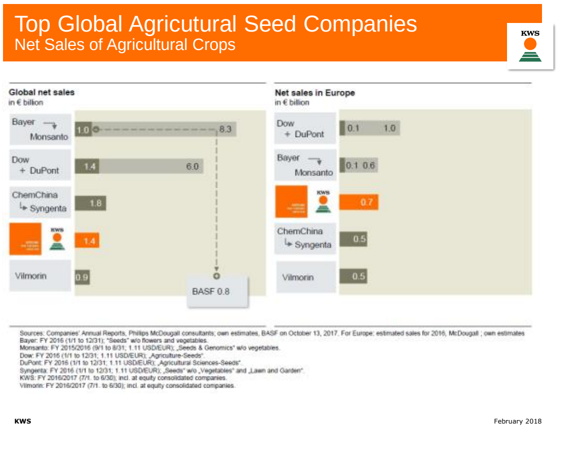
Thank you


KWS an Independent, Global Seed Company
February 2018
SEEDING THE FUTURE
KWS


The KWS Group
SEEDING THE FUTURE
KWS


Plant Breeding Serves Fundamental Demands
KWS
Population growth
Food demand is expected to rise by 60 % through 2050
Harvest losses
High harvest losses due to insects (15%), weeds (13%), fungal diseases (13%), damage in storage (10%)
Climate change
Change in abiotic stress requires new variety characteristics
Resource efficiency
Modern varieties need less input from limited resources like fertilizer, plant protection and fresh water
Steadily increasing demand for improved varieties
KWS
February 2018


Top Global Agricutural Seed Companies
Net Sales of Agricultural Crops
KWS
Global net sales
in € billion
Bayer
Monsanto
1.0
8.3
Dow
+ DuPont
1.4
6.0
ChemChina
Syngenta
1.8
KWS
1.4
Vilmorin
0.9
BASF 0.8
Net sales in Europe
in € billion
Dow
+ DuPont
0.1
1.0
Bayer
Monsanto
0.1 0.6
KWS
0.7
ChemChina
Syngenta
0.5
Vilmorin
0.5
Sources: Companies' Annual Reports, Phillips McDougall consultants; own estimates, BASF on October 13, 2017. For Europe: estimated sales for 2016, McDougall ; own estimates
Bayer: FY 2016 (1/1 to 12/31); "Seeds" w/o flowers and vegetables.
Monsanto: FY 2015/2016 (9/1 to 8/31; 1.11 USD/EUR); „Seeds & Genomics" w/o vegetables.
Dow: FY 2016 (1/1 to 12/31; 1.11 USD/EUR); „Agriculture-Seeds".
DuPont: FY 2016 (1/1 to 12/31; 1.11 USD/EUR); „Agricultural Sciences-Seeds".
Syngenta: FY 2016 (1/1 to 12/31; 1.11 USD/EUR); „Seeds" w/o „Vegetables" and „Lawn and Garden".
KWS: FY 2016/2017 (7/1. to 6/30); incl. at equity consolidated companies.
Vilmorin: FY 2016/2017 (7/1. to 6/30); incl. at equity consolidated companies.
KWS
February 2018

KWS Executive Board

Dr. Hagen Duenbostel
(1970)

- CEO/Member of the Executive Board since 2003
- Responsibility: Corn, Development & Communication, Compliance
- Degree in Business Administration; Dr. rer. pol.

Dr. Léon Broers
(1960)

- Member of the Executive Board since 2007
- Responsibility: Research, Breeding
- Ph.D. in Plant Breeding; Master of Business Administration

Dr. Peter Hofmann
(1960)

- Member of the Executive Board since 2014
- Responsibility: Sugarbeet, Cereals, Marketing
- Degree in Agronomy; Ph.D. in Seed Physiology

Eva Kienle
(1967)

- Member of the Executive Board since 2013
- Responsibility: Finance, Law, Procurement, Controlling, IT, HR, Global Services, Investor Relations
- Degree in Business Administration

KWS – Quick Financial Summary

Company highlights

- Strong market positions in the global agricultural crop market. Market leader in sugarbeets and hybrid rye
- Diverse gene pool with proprietary varieties
- Sustainable business model with strong fundamental pillars (global demand for food and feed)
- Strategy and management with long-term orientation, enabled by family shareholders

Key financials of the KWS Group

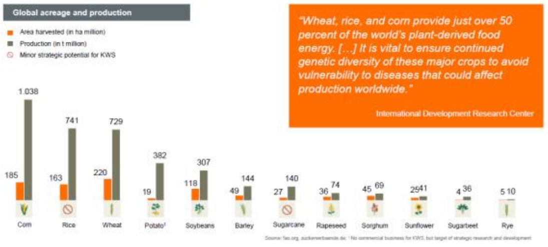
in € million	2016/2017	2015/2016	+ / –
Net sales	1,075.2	1,036.8	+3.7%
R&D expenses	190.3	182.5	+4.3%
EBIT	131.6	112.8	+16.7%
EBIT margin (%)	12.2	10.9	

Net sales by region

10-year sales development[1]

[1] Incl. our at equity-accounted joint ventures and associated companies

Global Importance of Agricultural Crops



"Wheat, rice, and corn provide just over 50 percent of the world's plant-derived food energy. […] It is vital to ensure continued genetic diversity of these major crops to avoid vulnerability to diseases that could affect production worldwide."

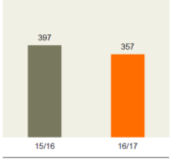
International Development Research Center

The KWS portfolio consists of a broad, proprietary, diversified genepool for the development of agricultural crops

The KWS Group – Business Unit Structure

The Key to Success: Efficient Variety Development

Marketing approvals for new varieties



R&D expenditure: 17.7% of net sales

Ø yield progress: 1% to 2% per year

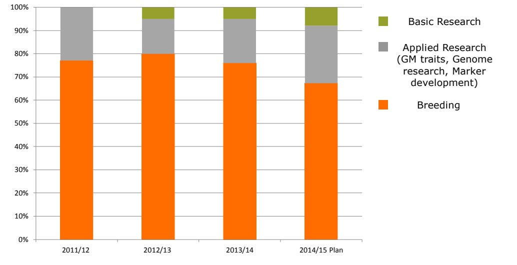
Phenotyping | Genomics & marker | Cell & tissue culture | GM traits

Genetic variation | Breeding competence | New breeding technologies | Bioinformatics

Global breeding activities of KWS

KWS R&D Budget

- Percentage of KWS research activities is continiously growing
- In 2014/15, 33% of R&D budget was used for basic and applied research



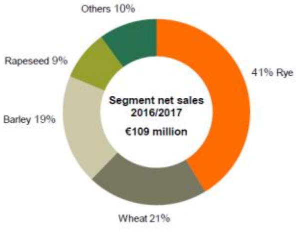
KWS Group Across the Globe

Breeding activities of the KWS Group

	2014/15
Companies in the group	65
KWS across the globe	71 countries

Wheat is Part of our Cereals BU Activities

Net sales breakdown
2016/2017



Breeding Wheat – Helping to Feed the World

Grain-based foods, like those produced with wheat, provide complex carbohydrates, which are the best fuel for our bodies, are low in fat, high in fibre and provide vitamins, especially the **4 key B vitamins, Thiamin, Riboflavin, Niacin, and Folic Acid, as well as iron**.

Breads	*A Host of non-food production including:*
Pasta	Starch Production
Breakfast cereals	Straw particle board (wood)
Biscuits	Paper
Crackers	Milk replacer
Bagels	Hair conditioners
Cakes	Adhesives on postage stamps
Animal Feed	Water-soluble inks
Wheat Distilling	Medical swabs
Thickening agents	Charcoal
Ready-made meals….	Biodegradable plastic eating utensils …

VERY DIVERSE QUALITY REQUIRING MARKETS

Overview of General Breeding Objectives for KWS

Yield

Sugar/energy/grain yield

Quality

Food, processing, fodder

Resistance

To diseases (e.g. fungi), to pests (e.g. insects) and abiotic stress

Nutrient use efficiency

Nitrogen, Phosphate

Agronomic properties

Hardiness, monogerm varieties, bolting resistance

Energy

Biomass/biogas yield, oil/starch/sugar yield

Specific Breeding Objectives for KWS Winter Wheat Breeding

1. Yield potential and stability

- Grain yield
- Winter hardiness
- Resistance to lodging
- Plant density
- Spike density
- Seeds per spike
- Thousand seed weight

With the exception of winter-hardiness abiotic stresses do not yet play a major role in our breeding targets

2. Resistance to diseases

- Stalk breakage
- Take-all
- Mildew
- Yellow rust
- Wheat leaf rust
- Septoria leaf blotch
- DTR Tan spot
- Fusarium head blight
- Glume blotch
- Viral diseases

3. Quality characteristics

Milling quality
- Ash content
- Flour yield
- Grain hardness

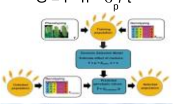
Ethanol quality
- Starch content
- Ethanol yield

Baking quality
- Protein content
- Sedimentation value
- Falling number
- Water absorption
- Pastry quality
- Baking volume

Key Breeding Drivers at KWS

- Access to excellent (proprietary) breeding material
  - Genetic resources / Genetic variability
- Focus on time to market
- Use of modern breeding technologies
  - Breeding methods (DH, GS, ..)
  - Phenotyping (Breeders eye, sensors, …)
  - Genomics and biotechnology (incl. traits)
- Efficient organization
  - Excellent employees
  - Efficient (breeding processes)
  - Integrated approach
- Innovation driven through research cooperation
- Strong link to market
  - Focus on quality
  - Appropriate variety protection

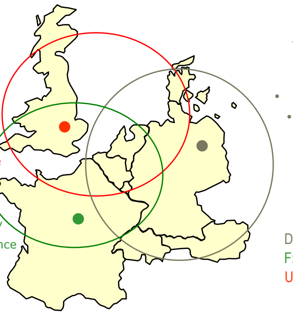
$G = i * h^2 * \sigma_p / t*$



KWS Wheat Breeding and Research - EU

United Kingdom
- HRW
- (HWW)
- SRW
- HRS
- very short and stiff plants
- yellow rust resistance
- insensitive to sowing time

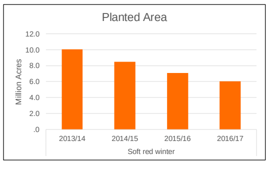
France
- HRW
- early maturity
- leaf rust resistance
- short plants
- quality



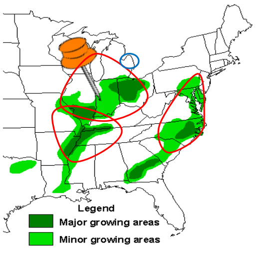
Germany
- HRW
- HRS
- Fusarium resistance
- winterhardiness
- quality

Acreage:
D: 8.0 Mio. acre
F: 12.5 Mio. acre
UK: 4.8 Mio. acre

KWS Wheat Breeding and Research – USA - SRW



- Total market ca. 7 mio ac
  - UMW ca. 2.5 mio ac
  - LMW ca. 2.0 mio ac
  - VA/ NC ca. 1.0 mio ac

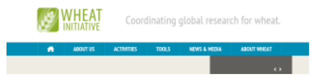


External Collaboration – KWS

- KWS has many collaborations with third party organisations
  - Universities
  - Research Institutes
  - Technology & Trait providers
  - Competitors (Pre-competitive R&D)
- A major theme for KWS has always been this '**collaborative**' approach, with **Germplasm Exchange** and the value of the '**Breeder's Exemption**' in PVR as cornerstones of how we work

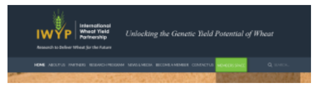
External Collaboration – Wheat Focus

- KWS interacts with many in R&D activities in wheat and values working with partners who are open-minded and genuinely value collaboration
- In Wheat we provide not only funding and in-kind contributions to research projects, we also provide staff to act on advisory boards and committees for many organisations
  - Government Departments, Research Funders, Universities etc.
  - Global International Projects (WI, IWYP etc.)



www.wheatinitiative.org

www.iwyp.org

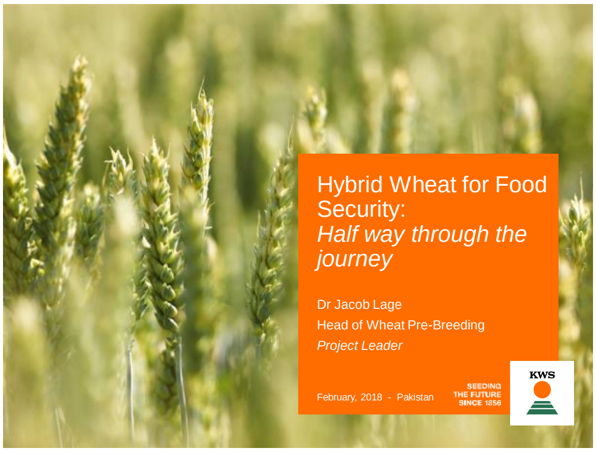


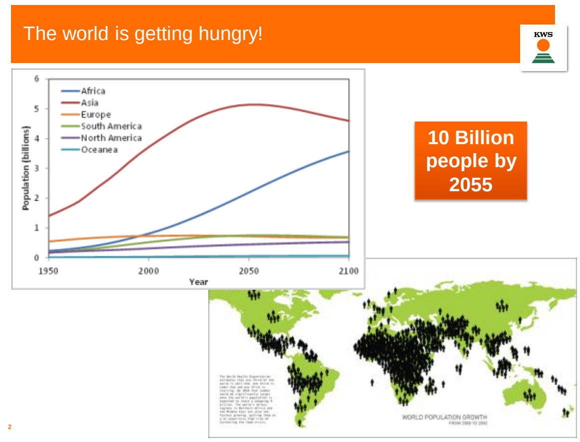
External Collaboration – Hybrid Wheat

- It is as part of our collaboration activities that we have become involved in the UK Government funded project on Hybrid Wheat that brings us to Pakistan today,

which is partly funded by the Department for International Development [DFID]

http://gtr.rcuk.ac.uk/projects?ref=101918


Hybrid Wheat for Food Security:
Half way through the journey
Dr Jacob Lage
Head of Wheat Pre-Breeding
Project Leader
February, 2018 - Pakistan
SEEDING THE FUTURE SINCE 1856
KWS


The world is getting hungry!
KWS
Africa
Asia
Europe
South America
North America
Oceanea
Population (billions)
0
1
2
3
4
5
6
1950
2000
2050
2100
Year
10 Billion people by 2055
WORLD POPULATION GROWTH
2


Food is a key component of security
KWS
Hunger → Conflict → Migration → Conflict
IMMIGRANTS OUT
FOREIGNERS GO HOME!
BORDERS
3


Hybrid wheat for food security – a shared vision
KWS
Norman Darvey
1945-2017
"we so often talk the talk, but we also need to walk the walk; deliver outcomes that matter, addressing global food needs"
4

Hybrid wheat for food security – UK-funded project

- Norman Darvey had a vision and an alternative hybrid wheat system
- Global group of partners
  - Norman Darvey
  - Universities of Agriculture Faisalabad & Multan
  - University of Sydney
  - KWS
- UK funding provided by the Department for International Development
- 5-year project

Kick-off meeting, Australia Oct 2015

5

Hybrid wheat for food security – objectives

- Develop hybrids for testing in Pakistan, Australia and Europe
  - Sydney, Prof. Richard Trethowan
  - UK, Nick Bird
- Improve Norman's hybrid system
  - Cytogeneticist Peng Zhong
- Exploit heterosis in Australian and Pakistani germplasm
  - Prof. Zulfiqar Ali and Mr Ishan Karim

Project meeting, Australia Oct 2016

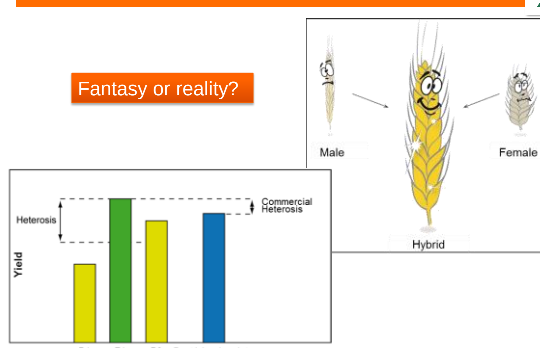
6

Hybrid Wheat

7

Hybrid wheat

Fantasy or reality?



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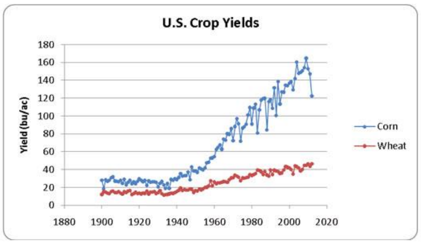
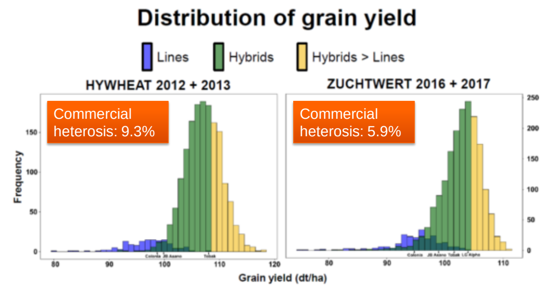
Hybrid wheat: why?



- 1909: Hybrid maize/corn "invented"
- 1924: First hybrid sold
- 1950: Most of US maize converted to hybrids

9

Hybrid wheat: yield gain

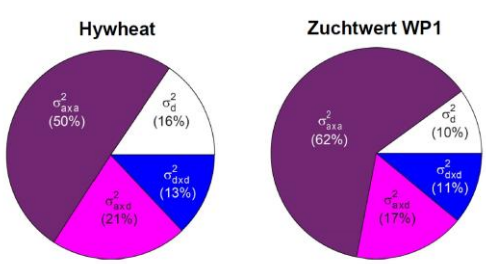


Best hybrid	Best line	Hybrids >lines
11.8 t/ha	10.8 t/ha	619

Best hybrid	Best line	Hybrids >lines
11.1 t/ha	10.4 t/ha	714

10

Hybrid wheat: where does the yield come from?



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Hybrid wheat: where to find heterosis and yield stability

♀ Females; ♂ males; ★ trial sites

12

Hybrid wheat: many benefits

- Money!
  - Increased revenue – for all
  - Possibly to move into regions currently determined as "unprofitable"
- Increasing yield
  - High yield potential areas: ~10%
  - Marginal environments: 15-25%
- Yield stability
  - Some anecdotal evidence that hybrid wheat has increased yield stability
  - Possibly more important than yield

13

Hybrid wheat: how to make wheat sterile?

- Chemical hybridisation agents (CHA)
- Genetic engineered nuclear-encoded systems
- Biological, native trait, systems
  - Cytoplasmic male sterility (CMS)
    - *Triticum timopheevii*
    - *Aegilops kotschyi*
  - Nuclear male sterility (NMS)
    - *ms1*
    - Environment sensitive genetic male sterility

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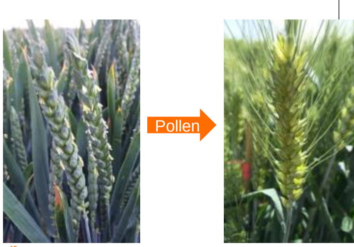
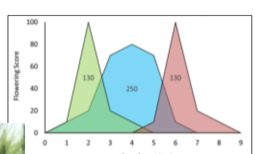
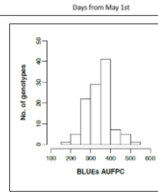
Hybrid wheat: floral biology is a key trait

- Self-pollinating -> cross-pollinating
  - Anther extrusion
  - Pollen production
  - Flowering duration







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Project update

The journey so far

16

The beginning

It all started in Norman's back garden

17

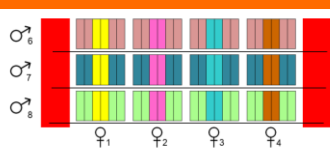
Scaling up

The work moved to University of Sydney's breeding station in Narrabri

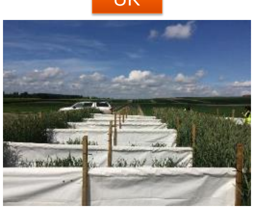
Mr Ishan Karim from University of Agriculture Faisalabad moved there for one year

18

First hybrids produced



UK

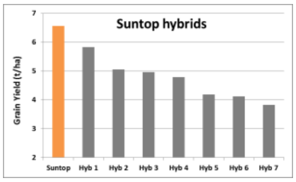


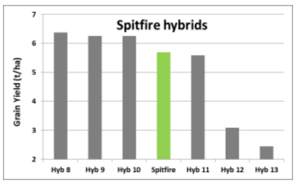
Australia

Hybrids tested – In Australia

20

Decent results from first year





21

Hybrids tested – In Pakistan

22

Hybrids tested – In South Africa

SENSAKO

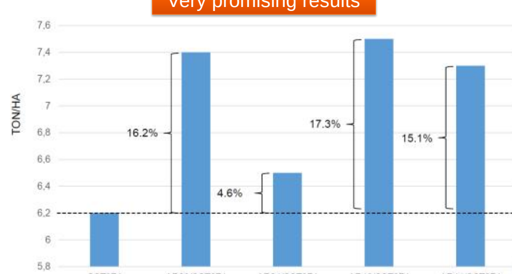
Beproefde Genetika • Proven Genetics

AR19/SST374

23

Hybrids tested – In South Africa

Very promising results



SENSAKO

Beproefde Genetika • Proven Genetics

24

Hybrids tested – In UK and Germany

25

Project meetings – In Pakistan

26

Project meetings – In Australia

27

Even made a visit to India

Indian Agricultural Research Institute (IARI) is a collaborator on project and will test hybrids in 2019

28

Had some failures

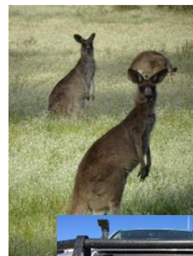
KWS

"If you never fail, then you are not trying hard enough"

29

…and some fun

KWS



and coffees

30

The second half of the project

KWS

- Pakistan
  - Multi-location yield trials with Pakistani hybrids
  - Quality test of hybrids
  - Production of new hybrids and initiate hybrid breeding
- Australia
  - Multi-location yield trials
  - Further improvement of hybrid system
- UK
  - Multi-location yield trials with hybrids based on KWS parents
- India
  - Multi-location yield trials with hybrids based on Indian parents

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Keep working together for food security

KWS

THANK YOU!

"We should all feel blessed by the privilege of working together in peaceful environments so that we can contribute to food production in the poor and hungry nations on earth"

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Molecular marker resources

- KWS' genotyping facility is based in Einbeck, Germany and handles samples from all KWS crops.

- The genotyping facility process approximately:
  - 55,000 wheat DNA extractions
  - 25,000 wheat samples run on arrays, predominantly for genomic selection
  - 50,000 Wheat KASP datapoints for MAS and research projects.

- KWS access all public resources for wheat genotyping
  - 9K Wheat Array (Illumina)
  - Wheat iSelect Array (Wang et al.)
  - Wheat 820K Array (Affymetrix)
  - 35K Wheat breeders array (Affymetrix)
  - 35K breedwheat Array (Affymetrix)

N BIRD KWS UK R&D 11/06/2018

Trait mapping to marker deployment

- For a specific loci the long term use of arrays is not cost effective.
- The faster the trait can be mapped and tracked using KASP markers the better.
- KWS Wheat pre-breeding in conjunction with the Biotechnology team employ a traditional approach to QTL mapping and gene cloning.

- Segregating populations are assessed phenotypically and lines are genotyped.
- Traditional QTL mapping conducted to determine region of interest.
- Depending on size of region further recombinant mapping maybe warranted.
- Recombinants in the QTL region are identified from the population and only these lines are phenotyped.
- Phenotypes and further genotyping of critical recombinants determine gene position.
- If sufficiently close enough, cloning by sequencing and / or candidate gene testing identifies the gene of interest.

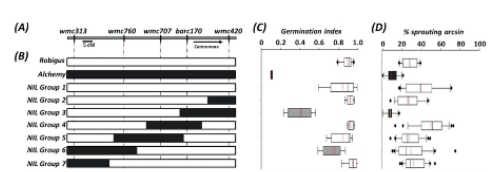
N BIRD KWS UK R&D 11/06/2018

Trait mapping to marker deployment

- Robigus x Alchemy population identified as having differential phenotypes in pre-harvest sprouting

- Traditional QTL mapping was done on a DH population identifying chromosome 4A

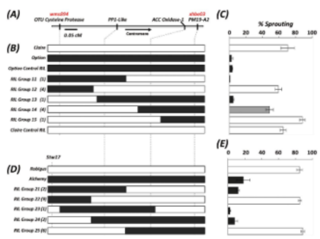
- NILs across the identified region were made for QTL validation



N BIRD KWS UK R&D 11/06/2018

Trait mapping to marker deployment

Recombinants in the region identified from 2 populations.
Further genotyping and phenotyping narrowed region allowing candidate genes to be identified



TaMKK-3 identified as causative gene via functional gene analysis

WAGTAIL

- Wheat Association Genetics for Trait Analysis and Improved Lineages.
- BBSRC funded project with NIAB and multiple commercial companies.
- Project started 2011 and ended in 2016.
- Project aims
  - Genetically fingerprint 480 predominantly UK winter wheat varieties.
  - Phenotype for the 5 major fungal disease in wheat.
  - Use genetics and disease scores to pinpoint sources of genetic resistance.
  - Confirm these sources of resistance in independent populations.

Yellow rust population changes

- 2013 saw massive shift in the UK yellow rust population.
- New race named the warrior race.
- In the following years yet more changes have occurred.
- Many efforts in trying to explain what has happened and managing the current situation are on going.

Results – Yellow Rust

- 12 resistance loci for yellow rust identified and validated post warrior race.
- No current variety has all 12 resistance loci.
- To date no information on which gene(s) is most effective.

- How are we using this information?
  - Number of resistance loci per variety information passed to breeders.
  - Maximum Yellow rust genetic performance per cross can be predicted.

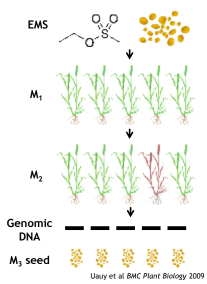
Max yellow rust genetic performance

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
	Parent YR loci	5	5	6	8	2	4	5	2	5	6	2	4	5	5	4	6	4	7	6	3	8	8	4	5	2	5	7	5
1	5	X	10	9	12	7	7	7	7	9	9	7	7	7	7	6	7	7	7	10	X	10	10	8	10	7	7	9	9
2	5	10	X	7	8	X	9	10	7	8	9	X	7	8	8	9	9	7	12	6	8	8	8	6	X	X	8	10	8
3	6	9	7	X	10	7	8	9	8	10	9	7	7	8	8	8	9	9	11	8	7	8	8	7	7	7	8	10	10
4	8	12	X	10	X	X	10	10	X	X	10	X	10	10	10	10	12	10	12	X	10	10	10	X	X	X	10	10	X
5	2	7	5	7	8	X	6	7	4	5	6	X	4	5	5	6	6	4	9	6	5	8	8	6	5	X	5	7	5
6	4	7	9	8	10	6	X	5	X	7	6	6	6	7	7	5	8	8	7	10	5	10	10	8	9	6	7	7	7
7	5	7	10	9	10	7	X	X	X	7	7	7	7	7	7	X	9	9	7	10	X	10	10	8	10	7	7	7	7
8	2	7	7	8	8	4	4	5	X	5	6	4	6	7	7	5	8	6	7	8	5	10	10	6	7	4	7	7	5
9	5	9	8	10	8	X	7	7	X	X	7	X	7	7	7	7	9	7	9	8	7	10	10	8	8	X	7	7	X
10	6	9	9	9	10	X	X	7	X	7	X	X	X	7	7	7	8	8	9	10	7	10	10	10	9	X	7	7	7
11	2	7	5	7	8	X	6	7	4	5	6	X	4	5	5	6	6	4	9	6	5	8	8	6	5	X	5	7	5
12	4	7	7	7	10	X	6	7	6	7	6	X	X	5	5	6	6	6	9	8	5	8	8	8	7	X	5	7	7
13	5	7	8	8	10	X	7	7	7	7	7	X	X	X	X	6	7	7	9	8	X	8	8	8	8	X	X	7	7
14	5	7	8	8	10	X	7	7	7	7	7	X	X	X	X	6	7	7	9	8	X	8	8	8	8	X	X	7	7
15	4	6	9	8	10	6	5	5	5	7	7	6	6	6	6	X	8	8	7	9	X	9	9	7	9	6	6	7	7
16	6	7	9	9	12	X	8	9	8	9	8	X	X	7	7	8	X	X	9	10	7	10	10	10	9	X	7	9	9
17	4	7	7	9	10	X	8	9	6	7	8	X	6	7	7	8	6	X	9	8	7	10	10	8	7	X	7	9	7
18	7	X	12	11	12	9	X	X	X	9	9	9	9	9	9	X	9	9	X	12	X	12	12	10	12	9	9	9	9
19	6	10	X	8	8	X	10	10	8	8	10	X	8	8	8	9	10	8	12	X	8	8	8	X	X	X	8	10	8
20	3	5	8	7	10	5	5	5	5	7	7	5	5	5	5	4	7	7	7	8	X	8	8	6	8	5	5	7	7
21	8	10	X	X	10	X	10	10	10	10	10	X	X	X	X	9	10	10	12	X	X	X	X	X	X	X	X	10	10
22	8	10	X	X	10	X	10	10	10	10	10	X	X	X	X	9	10	10	12	X	X	X	X	X	X	X	X	10	10
23	4	8	6	7	8	6	8	8	6	8	10	6	8	8	8	7	10	8	10	6	6	8	8	X	6	6	8	10	8
24	5	10	X	7	8	X	9	10	7	8	9	X	7	8	8	9	9	7	12	6	8	8	8	6	X	X	8	10	8
25	2	7	5	7	8	X	6	7	4	5	6	X	4	5	5	6	6	4	9	6	5	8	8	6	5	X	5	7	5
26	5	7	8	8	10	X	7	7	7	7	7	X	X	X	X	6	7	7	9	8	X	8	8	8	8	X	X	7	7
27	7	9	10	10	10	X	X	X	X	X	X	X	X	X	X	X	9	9	9	10	X	10	10	10	10	X	X	X	X
28	5	9	8	10	8	X	7	7	X	X	7	X	7	7	7	7	9	7	9	8	7	10	10	8	8	X	7	7	X

Maximising yellow rust genetic resistance

- This new genetic data is being used now.
- Profiling current lines in National testing.
- Designing the next set of crosses to be made as part of the breeding process.
- Contributing to decisions on acceleration of lines through the breeding process.
- All this information whilst being used currently in in-bred lines can and will form part of the breeding strategies for hybrid wheat.

Introducing novel allelic variation – The pipeline



- EMS mutagenesis introduces base pair substitutions leading to new alleles
- Exome capture and sequencing of M2 DNA identifies these base changes and can predict the effect on gene.
- 1200 mutated lines have been selfed to M4 families.
- The population has 6.4 million mutations in its exome.
- 70,000 predicted genes will have non-functional alleles
- Cadenza mutants being utilised in wheat pre-breeding program and multiple projects involving KWS

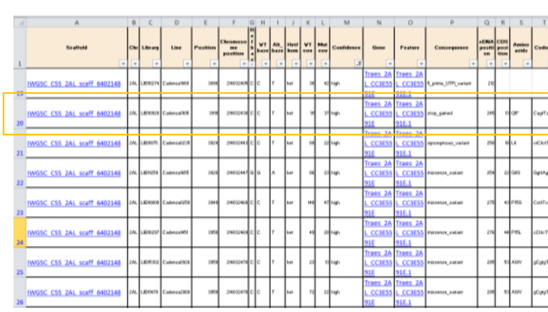
Introducing novel allelic variation – The pipeline

- Using Blast you can search for your gene(s) of interest.
- 10,000,000 mutant alleles across both tetraploid and hexaploid populations.
- Identify the most appropriate mutation (premature stop, splice site variant, etc).

Introducing novel allelic variation – The pipeline

WWW.Wheat-tilling.com

Introducing allelic variation – The pipeline

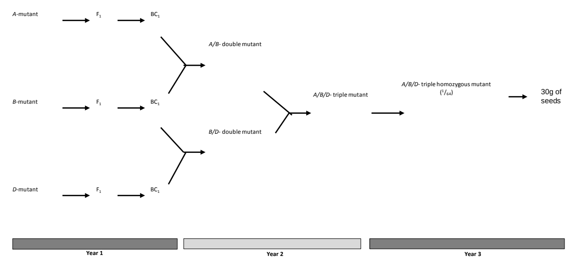


	Scaffold	Chr	Library	Line	Position	Chromosome position	Ref base	WT base	Alt base	Het/hom	WT cov	Mut cov	Confidence	Gene	Feature	Consequence	cDNA position	CDS position	Amino acids	Codons
19	IWGSC_CSS_2AL_scaff_6402148	2AL	[illegible]	[illegible]	[illegible]	[illegible]	C	C	T	het	[illegible]	[illegible]	high	Traes_2AL_CC3E5591E	Traes_2AL_CC3E5591E.1	5_prime_UTR_variant	[illegible]			
20	IWGSC_CSS_2AL_scaff_6402148	2AL	[illegible]	[illegible]	[illegible]	[illegible]	C	C	T	het	[illegible]	[illegible]	high	Traes_2AL_CC3E5591E	Traes_2AL_CC3E5591E.1	stop_gained	[illegible]	[illegible]	Q/*	Cag/Tag
21	IWGSC_CSS_2AL_scaff_6402148	2AL	[illegible]	[illegible]	[illegible]	[illegible]	C	C	T	het	[illegible]	[illegible]	high	Traes_2AL_CC3E5591E	Traes_2AL_CC3E5591E.1	synonymous_variant	[illegible]	[illegible]	L	[illegible]
22	IWGSC_CSS_2AL_scaff_6402148	2AL	[illegible]	[illegible]	[illegible]	[illegible]	G	G	A	het	[illegible]	[illegible]	high	Traes_2AL_CC3E5591E	Traes_2AL_CC3E5591E.1	missense_variant	[illegible]	[illegible]	G/S	[illegible]
23	IWGSC_CSS_2AL_scaff_6402148	2AL	[illegible]	[illegible]	[illegible]	[illegible]	C	C	T	het	[illegible]	[illegible]	high	Traes_2AL_CC3E5591E	Traes_2AL_CC3E5591E.1	missense_variant	[illegible]	[illegible]	P/S	[illegible]
24	IWGSC_CSS_2AL_scaff_6402148	2AL	[illegible]	[illegible]	[illegible]	[illegible]	C	C	T	het	[illegible]	[illegible]	high	Traes_2AL_CC3E5591E	Traes_2AL_CC3E5591E.1	missense_variant	[illegible]	[illegible]	P/L	[illegible]
25	IWGSC_CSS_2AL_scaff_6402148	2AL	[illegible]	[illegible]	[illegible]	[illegible]	C	C	T	het	[illegible]	[illegible]	high	Traes_2AL_CC3E5591E	Traes_2AL_CC3E5591E.1	missense_variant	[illegible]	[illegible]	A/V	[illegible]
26	IWGSC_CSS_2AL_scaff_6402148	2AL	[illegible]	[illegible]	[illegible]	[illegible]	C	C	T	het	[illegible]	[illegible]	high	Traes_2AL_CC3E5591E	Traes_2AL_CC3E5591E.1	missense_variant	[illegible]	[illegible]	A/V	[illegible]

Introducing allelic variation – The pipeline

- Using Blast you can search for your gene(s) of interest.
- 10,000,000 mutant alleles across both tetraploid and hexaploid populations.
- Identify the most appropriate mutation (premature stop, splice site variant, etc).
- 100,000 mutations will cause truncations (premature stop, splice site variant).
- Order these mutants (£250 each with FTO, £25 research only).
- Design KASP marker to track mutation using Polymarker (www.polymarker.tgac.ac.uk).
- Many targets need to be in homozygous null state in all 3 genomes for maximum (or sometimes any) effect to be seen.
- KWS have approximately 20 mutants in back crossing program at any one time.

Backcrossing scheme to KWS Variety



Summary

- KWS has a large genotyping facility which processes in excess of half a million samples a year.
- Approximately 10% of these samples are for the global wheat programs,
- Cost effective use of genotyping is essential to breeding programs.
- KWS are heavily involved in trait mapping and efficient usage of these traits in breeding programs.
- The UK wheat community collaborates closely in many projects to achieve more than any individual can.
- Effective utilisation of outputs from projects is essential to ensure progress.
- Public resources like the tilling libraries are opening up new, faster methods of genetic gain for public and commercial organisations.

STATUS OF WHEAT , CHALLENGES AND PROSPECTS OF WHEAT CULTIVATION IN PUNJAB/PAKISTAN

Dr. Makhdoom Hussain
makhdoomhussain@yahoo.com

AREA, PRODUCTION & YIELD OF WHEAT IN TOP 10 WHEAT PRODUCING COUNTRIES (2016-17)

Area (000) ha	Production (000) Tons	Yield Tons/ha
India (30600)	China (130000)	China (5.37)
Russia (28600)	India (98380)	Ukraine (4.02)
China (24200)	Russia (82000)	India (3.22)
USA (15211)	USA (47371)	USA (3.11)
Australia (12500)	Canada (27000)	Russia(3.06)
Pakistan (9050)	Ukraine (26500)	**Canada (3.00)**
Canada (9000)	**Pakistan (26200)**	Pakistan (2.90)
Turkey (7800)	Australia (21500)	Turkey (2.69)
Iran (6800)	Turkey (21000)	Iran (2.21)
Ukraine (6600)	Iran (15000)	Australia (1.72)

Global Wheat Scenario

- **Global Production** **742 mt**
- **Pak Production** **> 26 mt**
- **Punjab Production** **> 20 mt**
- **Pakistan** **7th Wheat Producer**

WHEAT YIELD INCREASE OVER THE YEARS IN PUNJAB - PAKISTAN

Year	Yield Kg/ha (Punjab)	Yield Kg/ha (Pakistan)
2014-15	2763	2726
2015-16	2817(2%)	2753(1%)
2016-17	3014(9%)	2900(6%)

Global wheat production during the current year is 742 million tons as compared to last year 754 million tons (- 1.62%)

WHEAT: PROJECTED REQUIREMENTS PAKISTAN

Year	Requirement (m. tones)	Av. Yield (tones/ha)
2020	28.8	3.2
2025	31.4	3.5
2030	34.3	3.8

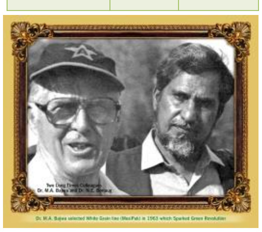
It includes human consumption (120 Kg / person with population growth of 1.8% per annum), feed and seed (10% of production), food security reserve (1.0 million tones)

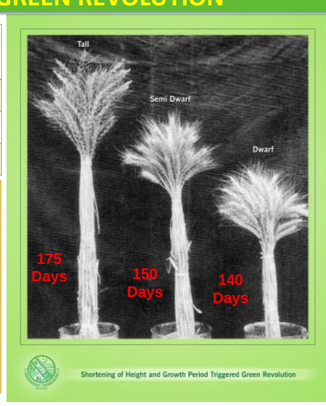
HISTORY OF GREEN REVOLUTION

- **Pakistan** 1965-66
- **Mexico** 1966-67 **India** 1967-68
  - It was a young Pakistani researcher (Dr. Manzoor Ahmad Bajwa) who, in 1961, selected the cross that later became known as MexiPak; a high yielding, white grain wheat that became one of the mega-varieties that launched the Green Revolution in the world.

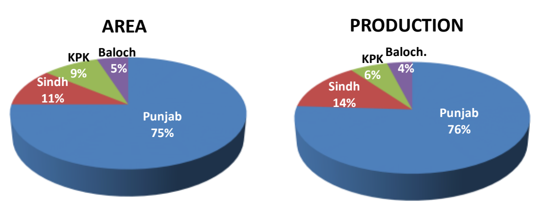
SHORTENING OF HEIGHT AND GROWTH PERIOD TRIGGERED GREEN REVOLUTION

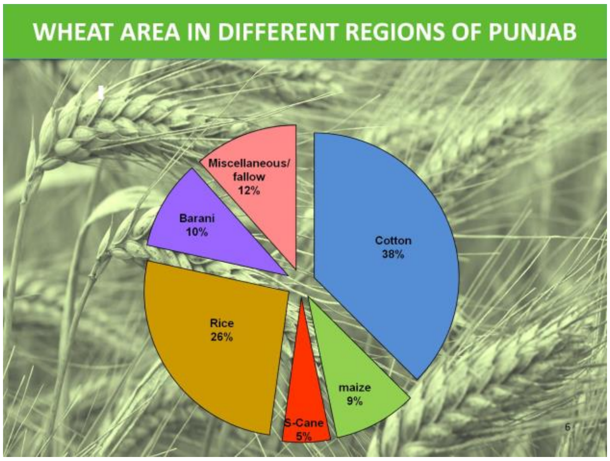
Name of variety	Plant Height	Maturity Days
C-591	150	175
Maxi Pak-65	115	150
Shafaq-06	80	140

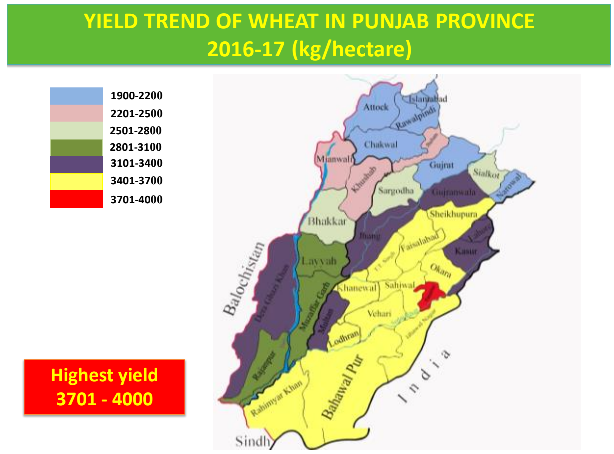




Provincial Share in Area and Production of Wheat

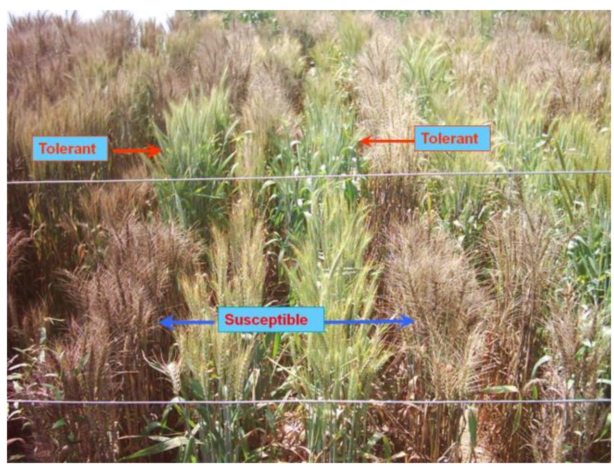






ISSUES/ CHALLENGES

- Climate change scenario
  - Drought (especially erratic rains in barani tract)
    rains, winds and hail storms at the time of harvesting
  - Frost stress
  - Terminal Heat Stress (Global warming)
    0.5ºC increase in temperature reduce wheat yield by 0.45 Tons/ha.
- Late wheat Planting
  - 17-20 kg/acre/day losses or 1% loss per day
  - Change in planting time
- Diseases especially rusts Up-to 70% loss
  - Change in appearance of rusts. (Lr - Yr - Lr)
  - Bunts
  - Wheat Blast Apparently not found in Pakistan
- Soil health, fertilizer (cost, availability & imbalanced use)
  Imbalanced Fertilizer = 30-55%
  Low organic matter = < 1%
- Insect/pest especially Aphid Up-to 40% loss
- Weeds
  Up-to 40% losses , resistance in weeds against weedicides
- Seed 20 – 25 % replacement annually
- Small holdings (80%) and Urbanization

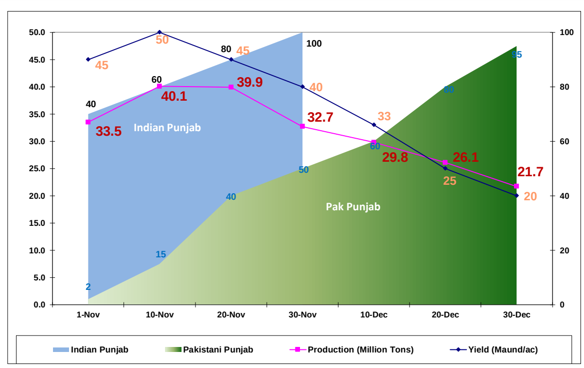


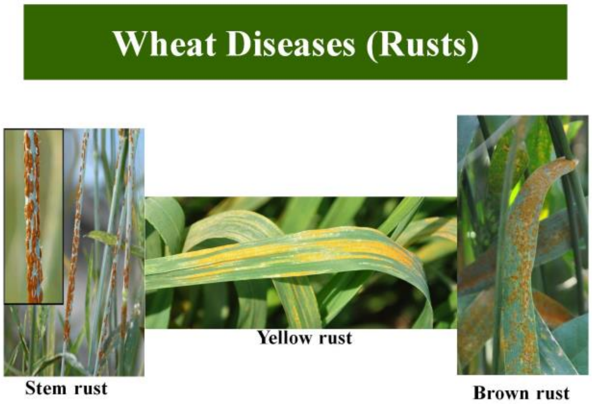
Frost stress

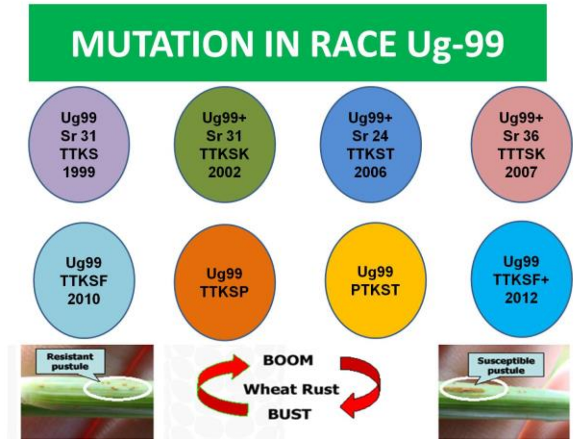
Frost stress

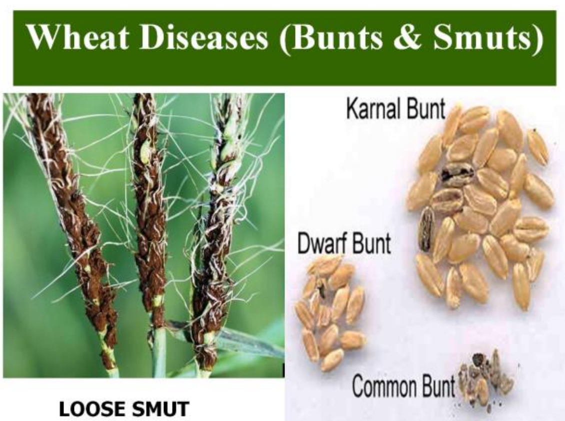
Frost (Intensity & effect)

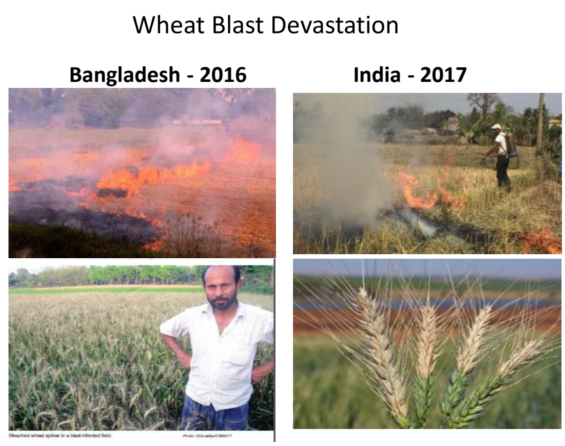
SOWING DATE PATTERN AND ITS IMPACT ON WHEAT PRODUCTION IN PUNJAB




Wheat Diseases (Rusts)
Yellow rust
Stem rust
Brown rust

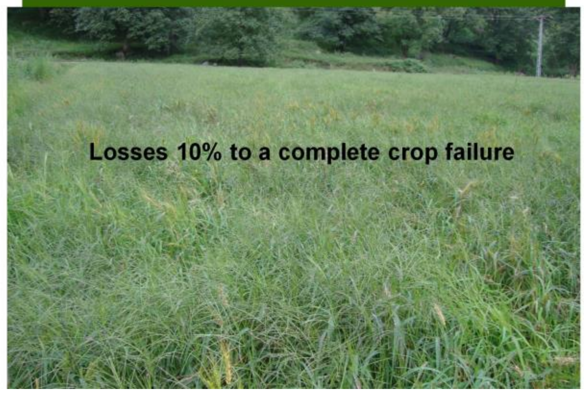

MUTATION IN RACE Ug-99
Ug99 Sr 31 TTKS 1999
Ug99+ Sr 31 TTKSK 2002
Ug99+ Sr 24 TTKST 2006
Ug99+ Sr 36 TTTSK 2007
Ug99 TTKSF 2010
Ug99 TTKSP
Ug99 PTKST
Ug99 TTKSF+ 2012
Resistant pustule
BOOM
Wheat Rust
BUST
Susceptible pustule


Wheat Diseases (Bunts & Smuts)
Karnal Bunt
Dwarf Bunt
Common Bunt
LOOSE SMUT


Wheat Blast Devastation
Bangladesh - 2016
India - 2017

Aphid (Coccinella spp)

Weed problem

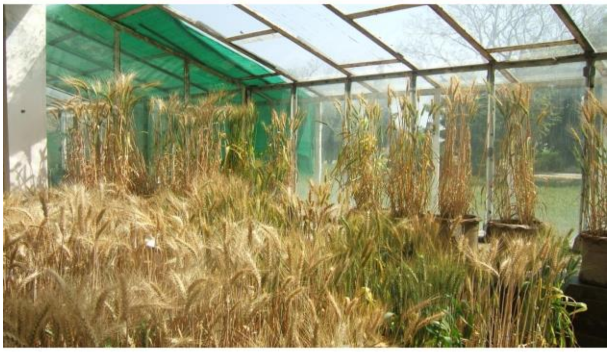


Problem Soils

Strategies to overcome effects of climate change

- Breeding strategies:
  - Breeding of heat, drought and frost tolerant varieties
  - Short duration wheat varieties
  - Physiological breeding using modern gadgets
    - Canopy temperature
    - Flag leaf stomatal conductance
    - Photosynthetic rate
    - Greenness
    - Electrolyte leakage (Cell membrane thermo-stability)
  - Use of molecular tools for efficient selection

Screening Against Heat



Strategies to overcome effects of climate change

- Management strategies
  - Change in cropping pattern
    - Include Pulses in rotation e.g. Wheat-Mung-Rice, etc.
    - Resource conservation.
    - Wheat planting in standing cotton.
    - Bed sowing to save water and to reduce lodging.
    - Zero till and direct seeded rice.
    - Sowing of wheat at proper time.
    - Application of Zinc to improve enzymatic reaction in plants.

Wheat In Standing Cotton

- No land preparation
- Cost saving
- Timely crop planting
- Builds soil organic matter
- Reduces compaction
- Improves yield
- Environment friendly

Zero Till Planting

- No land preparation
- Cost saving
- Timely crop planting
- Builds soil organic matter
- Reduces compaction
- Improves yield
- Environment friendly

Research Institutes Working on Wheat

- WRI, Faisalabad
- RARI, Bahawalpur
- BARI, Chakwal
- AZRI, Bhakkar
- Biotechnology, Faisalabad

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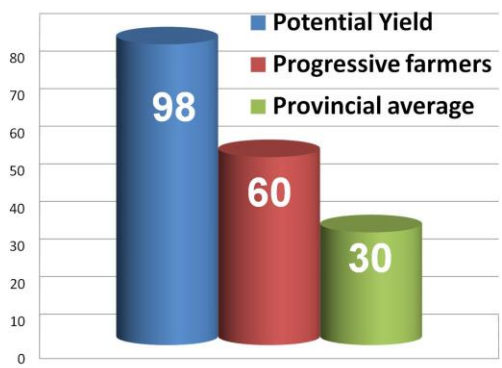
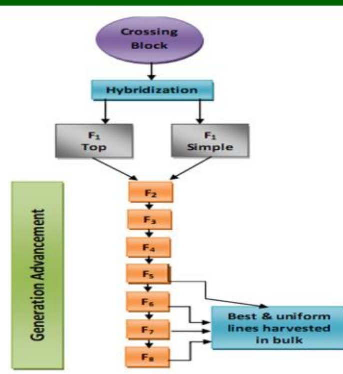
Research Disciplines

- Breeding
- Pathology
- Entomology
- Agronomy
- Quality
- Biotechnology
- Seed production
- Shuttle Breeding:
  - Kenya
  - Kaghan
  - Murree

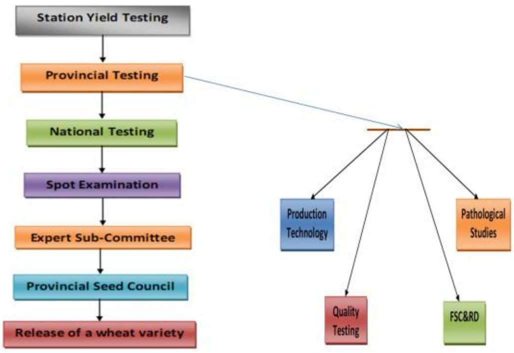
YIELD GAP (Maunds/ acre)



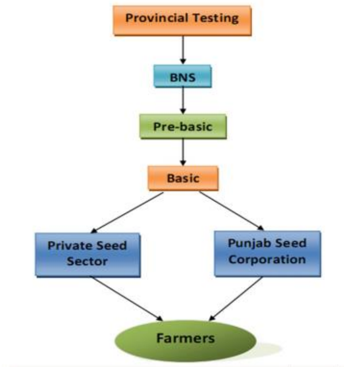
VARIETY DEVELOPMENT PROCEDURE



YIELD TESTING AND VARIETAL APPROVAL



SEED SYSTEM



Need for Quality Evaluation

National and International compulsions

Wheat variety development program

- Quick and reliable quality assessment
- Evolution of wheat varieties with good quality traits
- Resistant varieties
- Nutrient rich varieties

Wheat and milling tests

- **Moisture Content**
- **Ash Content**
- **Protein Content**
- **Thousand Kernel Weight**
- **Starch**
- **Gluten**
- **Sedimentation**
- **Single Kernel Characterization System (SKCS**

Flour and dough tests

- **Falling Number**
- **Flour Color Analysis**
- **Farinograph**
- **Extensograph**
- **Glutomatic**
- **Fermentograph**

Capacity Building

Trainings imparted

- **Training on Wheat Breeding/ Production Technology to:**
  - Master trainers of Extension Wing
  - Scientists from other provinces
  - Farmers
- **Rust Identification to:**
  - Extension wing of Agriculture
  - Pest Warning and quality control
- **Guidance/practical training to University students:**
  - Internship programme
  - Post-graduate & Ph.D. research

Capacity Building

Foreign Trainings Received

– Dr. Javed Ahmad	Kenya, USA, Mexico
– Dr. G.M. Subhani	Ethiopia, UK, Turkey
– Faqir Muhammad	Nepal
– Dr. M. Abrar	Singapore
– Anjam Javed	Singapore
– Nadeem Ahmad	USA, Mexico, Kenya
– Muhammad Hussain	USA
– Faqir Muhammad	Mexico
– Dr. M. Akbar	Mexico
– Javed Anwar	Syria
– Sabina Asghar	Nepal, USA, Mexico
– Muhammad Zulkiffal	Mexico
– Huma Safdar	USA
– Rabia Sultan	USA
– Dr. Makhdoom Hussain	USA, Russia, Nepal, Mexico, Syria, Turkey, Australia, Kenya

Visit of international scientists

Dr Norman E. Borlaug	CIMMYT	Dr Micheal Jones	Australia
Dr Mathew Reynolds	CIMMYT	Dr Hans Braun	CIMMYT
Dr Rick Ward	CIMMYT	Dr David Marshall	CIMMYT
Dr Osman Abdallah	ICARDA	Dr Xian Ming	USDA, USA
Dr Michael Baum	ICARDA	Dr K.D. Joshi	CIMMYT
Dr Zewdie Bishaw	ICARDA	Dr Abdul Rahman Bashir	CIMMYT
Dr Kumarse Nazari	ICARDA	Dr Upali Samarajeewa	Sri Linka
Dr Akram Khan	Australia	Dr L. G. Wigemark	EU
Dr Javed Iqbal	USA	Dr Anne Mackanze	FAO
Dr Alistair Pask	CIMMYT	Dr I. W. Borne	USDA
		Dr Kulvender Singh	UC DAVIS

Training of WRI Staff by Foreign scientists

Farmer interaction

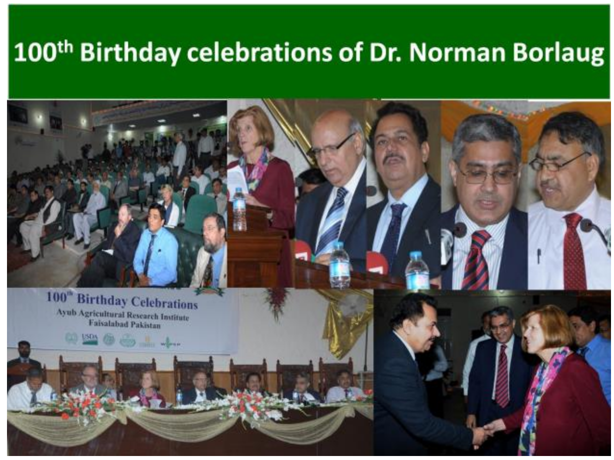
Farmer's days arranged by WRI at farmers fields

Farmer's days arranged by WRI

Farmer Days

Seed Distribution


Demonstration on farmers fields


100th Birthday celebrations of Dr. Norman Borlaug
100th Birthday Celebrations
Ayub Agricultural Research Institute
Faisalabad Pakistan


100th Birthday celebrations of Dr. Norman Borlaug

Achievements of AARI in 2016-17

Six wheat varieties released

- Ujala-16 Johar-16 Gold-16
- Ihsan-16 Fatehjang-16 Anaj-17

Two Barley Varieties

- Jau-17 Sultan-17

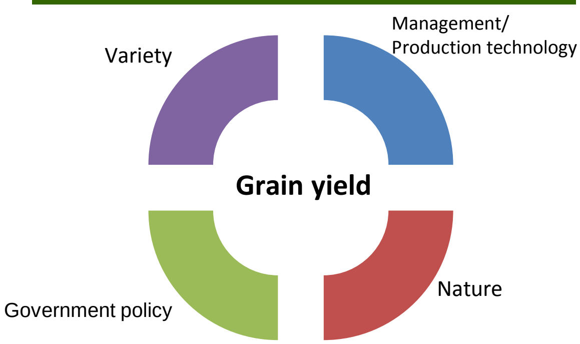
- Advance line (V-12066) found resistant to all 3 rusts on the basis of two year studies by CDRI, Islamabad.
- Advance line (V-14154) performed excellent on Pakistan basis with yield of 4329 kg/ha and was on top position with yield of 4266 kg/ha on Punjab basis in NUWYT 2016-17.
- Wheat line (V-14124) attained top position in PUWYT 2016-17 producing 4360 kg/ha.

Achievements of AARI in 2016-17

Six w Cereal Technology Laboratory got accredited " ISO – 17025 "

1st Lab in the history of Research Wing.

Yield Contributors



Record Production in Punjab (2016-17)

Production > 20 mt

Due to

- **Availabilities of good varieties**
- **Good Management Practices**
  (Balance use of fertilizer, availability of irrigation water, weeds control)
- **Better Government Policies**
  (Subsidized inputs, provision of certified seed, loan & machinery)
- **Favorable weather conditions**
  (less fogy days, cool nights, favorable temp. at grain fill stage, less lodging & rust attack)
- **It was all due to the blessing of Almighty Allah**

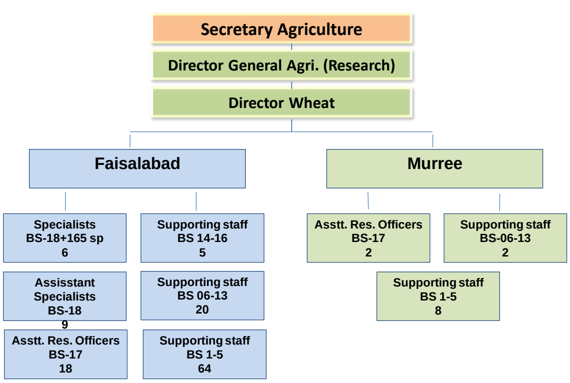
Economic worth of wheat over the year in Punjab

Particular	Production (000) Tons
2015-16	19527
2016-17	20466
Increase over the year	939
Economic worth (Billion Rs.)	
• Wheat Grains	30.52
• Wheat Bhoosa	7.04
Total worth:	37.56

VISION FOR RESEARCH

- Breeding for Nutrition Enhancement in wheat (Genetic, bio-fortification & value addition) to overcome malnutrition problems
- Development of zone specific wheat varieties suitable for different cropping systems under changed climate scenario (Special focus in rice zone).
- Development of stress resilient wheat varieties (Drought, Terminal Heat Stress, Frost, Salinity and Diseases)
- Development of nutrient efficient varieties and Integrated plant nutrient Management system

Organizational structure/ hierarchy



Scientists of WRI, Faisalabad

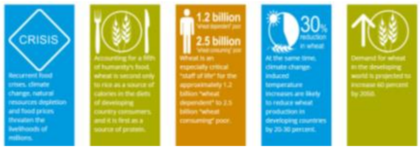

Thanks

MNS University of Agriculture, Multan

Architecting Self-Irrigating Wheat Through Fog Capturing

Zulfiqar Ali PhD
Professor and Chairman
Department of Plant Breeding and Genetics

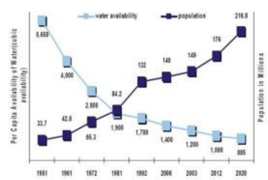
Rationale



Abrupt climatic changes - drought spells and heat waves

More frequent and intense in the coming decades

Rationale



Pakistan is 7th most vulnerable country

Contact angle

Θ a	=	98
θ r	=	56
θ a-r	=	42

α > 13.7

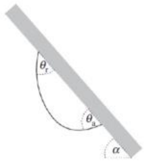
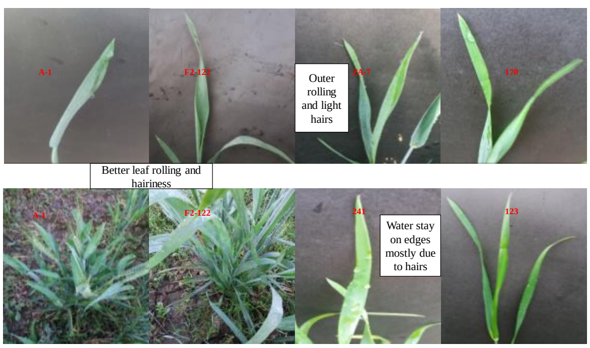


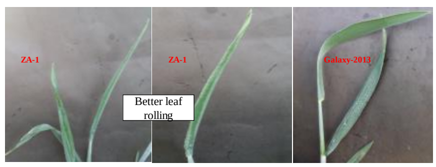
Figure 8. Droplet hanging down from a plane which is inclined against the horizontal axis by an angle α. θ_r and θ_a denote the receding and advancing contact angle, respectively.

Objectives and outcomes

Development of drought and heat tolerant wheat germplasm

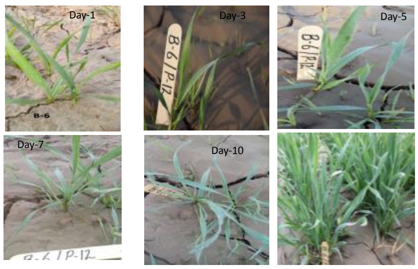
- An assembly of novel leaf surface structural traits
  - erect leaves with minimum leaf-to-stem angle
  - leaf rolled longitudinally
  - leaves having prickle hairs
  - grooves running parallel to the long axis of the plan
- Information on morphological and cytological bases of drought and heat tolerance
- Drought and heat tolerant wheat germplasm





Genotype	Prickle Hairs	Leaf Rolling	Leaf Angle	Groove Type
ZA-1	8	1	1	1
Galaxy-13	7	2	2	2

Genotype	Moisture %
ZA-1	11.12
Galaxy-13	8.04



Genotype	Moisture	
	Root Zone	Vicinity
B-6	7.2	4.1

Genotype	Prickle Hairs	Leaf Rolling	Leaf Angle	Groove Type
B-6	1	4	1	4

Genotype	Moisture	
	Root Zone	Vicinity
A-1	5.0	3.4

Genotype	Prickle Hairs	Leaf Rolling	Leaf Angle	Groove Type
A-1	8	2	2	2

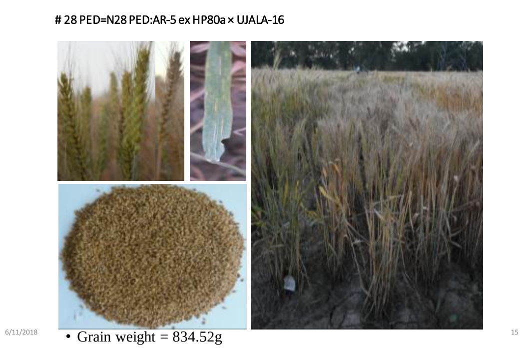
Genotype	Moisture	
	Root Zone	Vicinity
Chakwal-86	5.6	4.5

Genotype	Prickle Hairs	Leaf Rolling	Leaf Angle	Groove Type
Chakwal-86	7	1	1	1

18-01-18

23-01-18

28-01-18



Acknowledgement

US-PCAS-AFS

PARB

UC Davis

Faculty and students

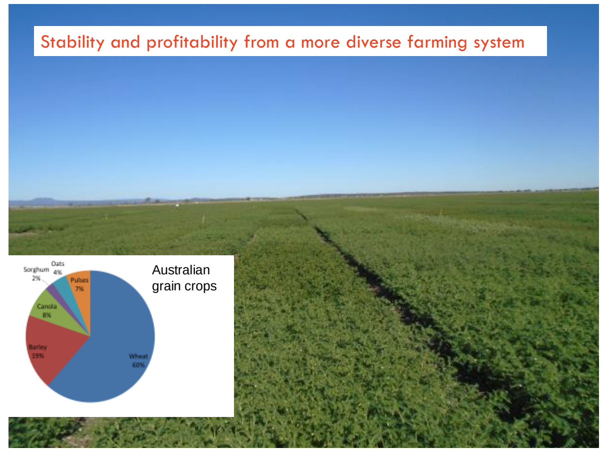
6/11/2018 17

Thank you

Chickpea pre-breeding and research for temperature tolerance

Presented by
Richard Trethowan
'Legumes for Sustainable Agriculture'

THE UNIVERSITY OF SYDNEY
LEGUMES



Legumes for Sustainable Agriculture

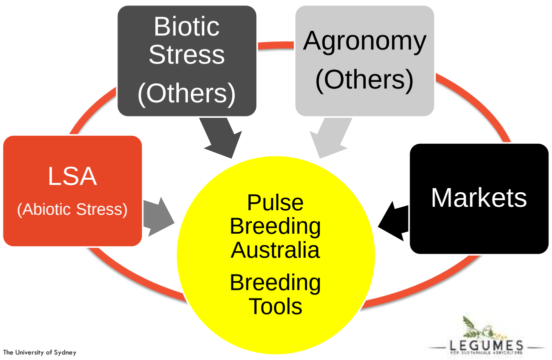
- A **National Research HUB** focused on improving grain legume productivity and agricultural sustainability
- Capture diverse and complimentary plant-based skills for **Grain Legume Focus**
  - Plant Physiology
  - Biochemistry and Molecular Biology
  - Symbiotic biology and soil interactions
  - Genetics and Pre-breeding
- Identify new traits that improve legume productivity in Australia
  - Pre-breeding pipelines to translate discoveries for use by breeders
- Compliment existing legume research streams in Australia

Partnerships and Investors

Australian Government
Australian Research Council
GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION
THE UNIVERSITY OF SYDNEY
THE UNIVERSITY of ADELAIDE
Australian National University
THE UNIVERSITY OF WESTERN AUSTRALIA
Flinders UNIVERSITY
NC STATE UNIVERSITY
LA TROBE UNIVERSITY
NSW GOVERNMENT
SARDI
WRF

- ARC, GRDC
- Universities (7)
- State-based agencies (2)
- Wheat Research Foundation
- ~$14.5 million (cash and in-kind)
  - 5 year research program

Complementary R&D within Australia



LEGUMES

LSA Research Aims

Chickpea

- Develop grain legumes for increased resilience to abiotic stress.
- Optimize plant resource partitioning to enhance the efficiency of yield production under stress.
- Enhance N_2-fixation of grain legumes for annual and rotational crop production.

Drought
Salinity
Heat
Flooding

Carbon
Nitrogen

Nodules
N-fix
N-soil
Symbiosis

How do chickpeas respond to temperature?

THE UNIVERSITY OF SYDNEY

Genetic diversity in Australian chickpea is low

There is relatively little genetic variation in Australian cultivars relative to other crops.

- The industry is relatively new
- Many cultivars share a parent
- The chickpea gene pool is narrow

Chickpea domestication (Abbo et al. 2003)

- Chickpeas were domesticated as a spring-sown crop (Mediterranean) due to high susceptibility to Ascochyta
- With improved Ascochyta resistance and a wider range of growth environments (including many with conditions less conducive to Ascochyta) it has reverted to an autumn sown crop in most places (except Europe)
- This had consequences on the vernalisation, light intensity and phenological requirements of the crop
- Wild relatives hold significant diversity compared to cultivated forms, and significant room for improvement

Chickpea temperature response

Extremes → reproductive tissue damage → low yields

- Flower sterility
- Pod abortion
- [Economic losses due to heat stress marks on grain]

Low or high temps → phenological/growth rate changes → low yields

- Delay in flowering/podset (heat stress during pod fill)
- Early onset podding (frost risk during pod fill)

BREEDING STRATEGIES for HEAT STRESS TOLERANCE

Breed for earlier podding
(**heat avoidance**)

Improve podfilling under high temperatures
(**heat tolerance**)

BREEDING STRATEGIES (cont.)

Import new lines

- ICRISAT
- Global Hot Spots
- Other researchers
- Aus. Gene Bank

Why are they heat tolerant?

- Growth chambers
- Mapping the genes
- Aerial imagery
- …etc

Field-based heat tolerance/avoidance screening

– Normal NW NSW sowing time (late May) = TOS1
– Delayed sowing to cause heat stress during pod filling (late July) = TOS2

– Control for optimum nutrition, non-limiting water availability, minimal disease

– Quantify growth rate, yield, grain size

Selecting for yield under heat

– Limit to yield is podding date, not flowering date, amongst Aus. Cultivars
– Can we improve yield by bringing forward podding date?
– Can we improve yield by breeding for heat tolerance in plants during podfill?

AIMS

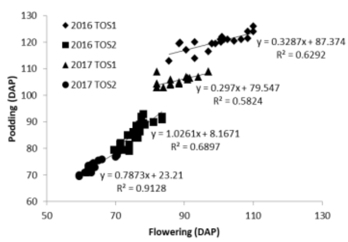
Part 1 – Investigation of early phenology (for heat avoidance)
Part 2 – Investigation of yield under delayed sowing (for heat tolerance)

Part 1. Phenology and temperature stress

– Flower-pod interval in commercial farms can be up to a month
– Data from TOS 1 = average 21 days or 19 days 2016 or 2017
– Farmers report the need of a 'heat kick' to flower or pod
– Is this GDD, plant response to a 'kick', daily temps reaching a high enough level, or something else?

When late sown (assuming no extreme temp to prevent podding), flower-pod interval is typically 11 days

Relationship between flowering and podding



Phenology + Growing Degree Days

	Flowering		Podding	
	TOS1	TOS2	TOS1	TOS2
2016	999	892	1374	1044
2017	940	729	1167	921

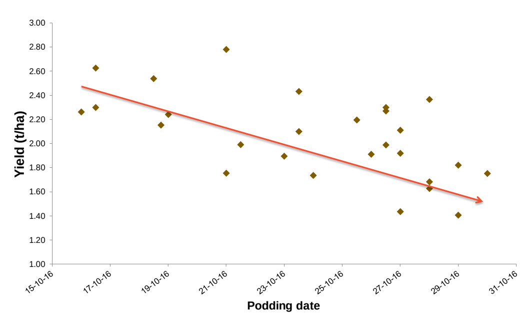
Accumulated GDD up to the commencement of flowering and podding for the earliest genotypes in each treatment

Phenology + Light intensity

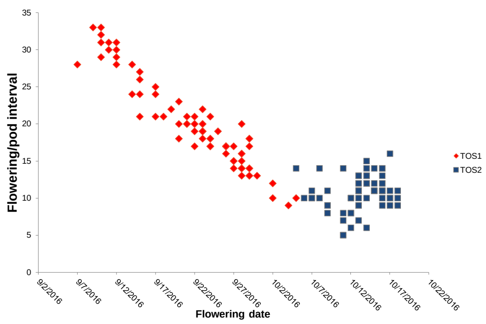
	Flowering		Podding	
	TOS1	TOS2	TOS1	TOS2
2016	410	424	602	525
2017	401	421	579	479

Accumulated Photosynthetically-Active Radiation (PAR, in MJ m^{-2}) up to the commencement of flowering and podding for the earliest genotypes in each treatment

Will early podding help in an Australian Environment?



Genotypic variation in flower/pod interval at different flowering dates



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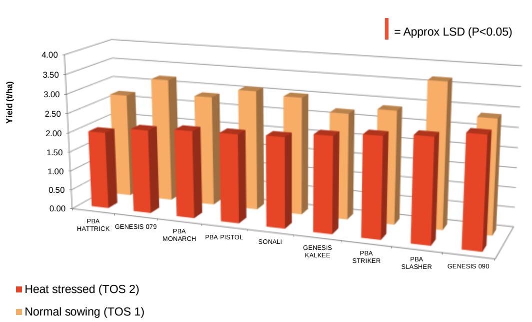
Part 2. Yield under heat stress

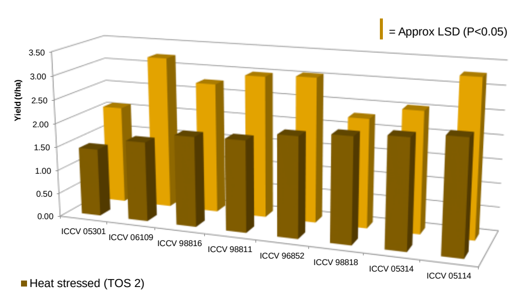
Considering heat tolerance, two ways to look at results:

- *Yield loss (genetic potential)*
- *Physiological basis of high/poor yield when heat stressed (trait identification)*

Genotype yield responses to sowing date (Australian varieties)



Genotype yield responses to sowing date (introduced materials)

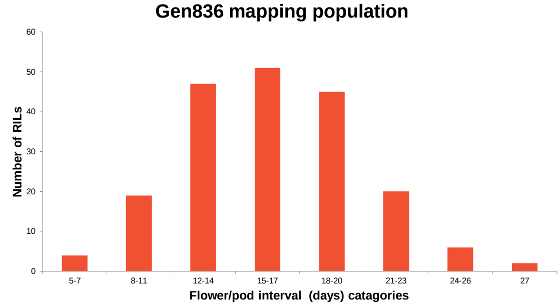


Mapping the genes for heat tolerance

Sonali x PBA Slasher (early podding x heat/drought tolerant)
ICCV 06302 x Genesis 079 (heat tolerant x drought tolerant)
Rupali x Genesis 386 (early podding x normal podding) [from ACPFG]

Currently under seed increase for 2018 experiments

Histogram of flower/pod interval in Rupali x Gen836 mapping population



Acknowledgements: Angela Pattison & Helen Bramley

PAKISTAN AGRICULTURAL RESEARCH COUNCIL

Pulses in Pakistan Challenges & Prospects

International seminar on Pulses and Wheat for Food Security
25-02-2018
MNS University of Agriculture, Multan

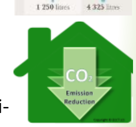
Dr. Shahid Riaz Malik
Program Leader, Pulses Research
National Agricultural Research Center
Islamabad

Pulses: Powerful Super food

- Zero Cholesterol
- Source of Protein
- Rich in Minerals & B-vitamins
- Low Glycaemic index
- Rich in Nutrients
- Low fat contents
- Gluten Free
- Source of dietary Fiber

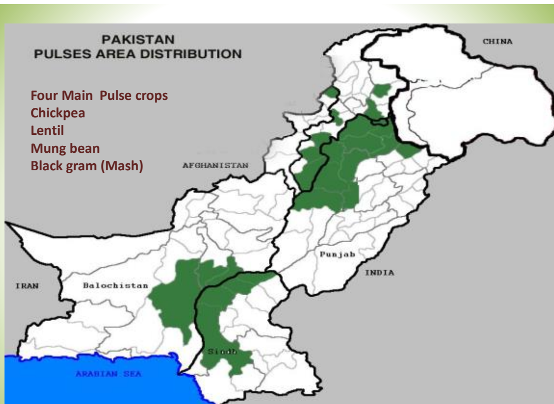
Other benefits

- Foster Sustainable Agriculture and soil Protection
  - Nitrogen Fixing properties
- Highly Water Efficient
- Ally against climate change
  - Broad genetic diversity
  - Smaller Carbon footprints
- Economically accessible and multipurpose
  - Can be cultivated in poor soils and semi-arid environments
  - Farmers can produce for eating and/or selling
  - Crop residues/straw as animal fodder

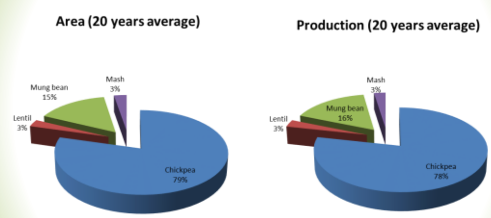


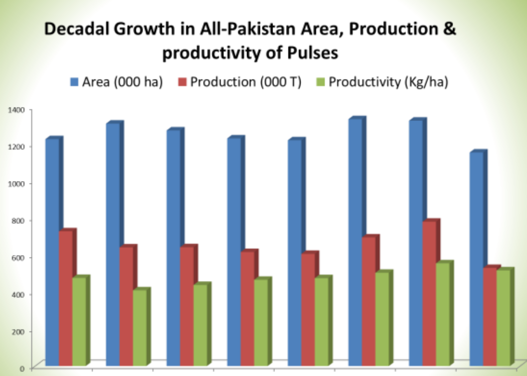
Pakistan Agriculture: Basic Facts

- Total cropped area : 22.51 m ha
- Pulses : 1.13 m ha (5%)
- Cereals : 12.603 m ha (56%)
- Cash crops : 4.343 m ha (19%)
- Edible oilseeds : 0.694 m ha (3%)
- Pulses-cereals ratio : 1:8.5
- Pulses Per capita availability : 6.5 kg/annum



Percentage Share of Four Major Pulses





Source: Agriculture Statistics of Pakistan

Consumption Production Comparison

(2015-16)

Quantity in '000' tonnes

Crop	Consumption	Production	Import	Import Dependency (%)
Chickpea	550	286	264	48
Mung Bean	160	102	58	36
Lentil	113	7	106	94
Mash	69	9	60	87
Total	892	404	488	55

Source: M/O NFS& R, Islamabad

Pulses area, production & yield 2016-17

Crop	Area (000 ha)	Production (000 t)	Yield (kg/ha)
Chickpea	931	359	386
Lentil	14	6.4	457
Mung bean	179	130	726
Mash (black gram)	17.1	7.2	421

Source: Agriculture Statistics of Pakistan, 2016-17

Pulses Import 2016-17

Crop	Quantity (T)	Value (MPKR)
Chickpea	488049	44254
Lentil	193332	15092
Mung bean	2649	183
Mash (Black gram)	61207	7234
Kidney beans	79498	5689
Dried Peas	376328	25445
Others	24308	1814
Total	**1225371**	**99721**

Source: SA, (CP&L), BPS, Islamabad 2017

CHALLENGES

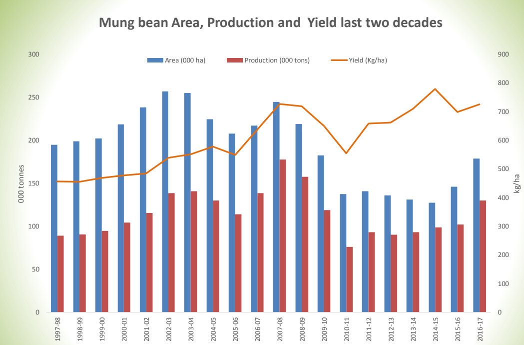
- Mostly grown under rain-fed marginal conditions; considered as secondary crops except Mung bean
- Drastic decline in area: especially in lentil and mash due to incentive rice-wheat production
- Instability in Yield; prone to a range of biotic and a-biotic stresses
- Changing climate: emerging new stresses
- Low yield potential: limited use of wide range of genetic diversity and desirable genes

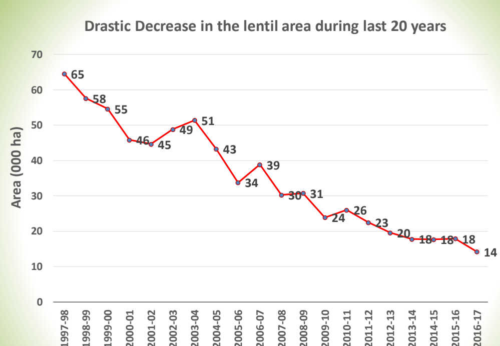
Contd.

Chickpea Area, Production and Yield Last two decades

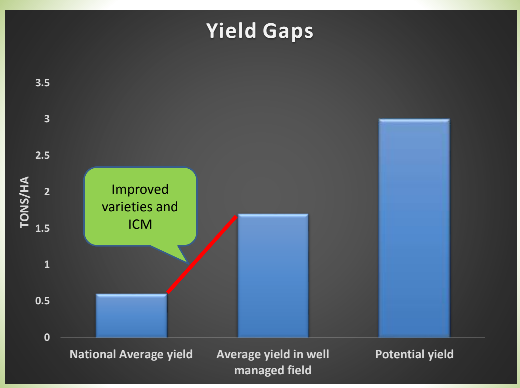
Chickpea crop when timely rainfall

No rainfall after planting





- Use of less inputs by farmers
- Govt. policies favor cereals production
- Limited access to quality seed of improved varieties
- Lack of mechanization
- Low investment in Pulses R&D
- Poor transfer of technology



Factors responsible for yield gap

- Research/Management
  - Improved seed
  - Chemical weed control
  - Optimum plant population
  - Planting method (line vs Broadcast)
  - Optimum planting time
  - Ensured moisture availability at critical stages
  - Nutrient management
  - Crop mechanization
  - Appropriate plant protection measures especially in irrigated areas (pod borer in chickpea, white fly and thrips in mungbean)
  - Diseases (Blight and wilt in chickpea)
- Policy
  - Fixation and implementation of encouraging price
  - Timely availability of quality inputs
  - Regulation of imports and exports

How to bridge Yield Gap

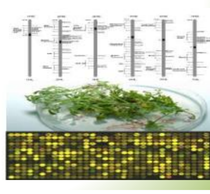
- **Promotion of Quality seeds**
  - Certified seed through NARS, public and private seed companies
- **Good Agronomic Practices**
  - Dissemination of new technologies
- **Mechanization**
  - Especially harvesting to minimize losses
- **Value Chain Development**
  - Development of agribusiness services to support small holders
  - Encourage the development and supply of tools for producing and processing pulses
  - Minimize the role of intermediaries
  - Value addition and collaboration with food sector

Prospects

- Research and development
  - Increase investment in R&D
- Genetic gains: Exploitation of germplasm resources and wild accessions for breaking yield barriers
  - ➢ Traits in focus
  - Resistance to diseases
  - Heat and drought tolerance
  - Resistance to insect pests
  - Herbicide tolerance
  - Machine harvesting
  - Improved plant architecture
  - High input responsiveness

Integration of technologies

- Conventional Breeding
  - Selection of parents
  - Hybridization
  - Selection
  - Trials
- Biotechnology Tools
  - Genomics
  - Marker assisted selection
  - Tissue culture
  - DNA fingerprinting
  - Genetic engineering



- Agronomic
  - Refined /improved production technologies
  - Encourage crop diversification (intercropping, catch cropping)
  - Effect weed management
  - Nutrient management especially Rhizobium inoculation
  - Integrated pest management
- Socio-economic
  - Value chain management from farm level production to post-harvest process, packaging, transportation and marketing to improve incomes of smallholders
  - Establish 'Seed Villages' to address concerns related to quality seed production and availability

- Policy
  - Expansion in area: exploring new niches for introduction of pulses cultivation & crop diversification
  - Build capacities of farmers with use of information communication technologies and mobile applications through educated youth, men and women
  - Increase public awareness of health and nutritional benefits of pulses; deploy on-farm, participatory adaptive research and developmental approaches for technology adoption
  - Improved agronomic practices awareness to bridge yield gap, minimize pre and post-harvest losses and enhance income of smallholders who mostly cultivate pulses
  - Support prices/incentive or buy back mechanism
  - Ensure timely availability of quality inputs

New Initiatives

- Mega Coordinated Project on Pulses "PROMOTING RESEARCH FOR PRODUCTIVITY ENHANCEMENT IN PULSES" submitted by PARC to GOP.
  - Genetic Enhancement
  - Improvement of production technologies
  - Mechanization
  - Seed supply

Strengthen International collaboration

Australian Government
Australian Centre for International Agricultural Research

Chickpea and Lentil

ICARDA
Science for Better Livelihoods in Dry Areas

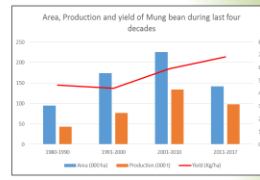
Kabuli Chickpea and Lentil

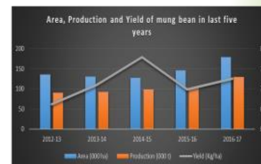
World Vegetable Center

Mung bean and Black gram

Mung bean: Success story in Pakistan

- **Increase in area, production and yield due to**
  - Start of Collaborative research work of national and international institutes.
  - Development and Adoption of short duration, resistant to MYMV disease, more compact, having a high harvest index, reduced photoperiod sensitivity, synchronous maturity, bear pods at the top in bunches, have long pods with bold, shiny seeds and high yielding varieties.
  - Inclusion of mung bean in irrigated areas and other cropping systems as catch crop, double crop and intercrop.
  - Improvement in production technologies
  - Post-emergence weedicides are available
  - Mechanized harvesting by combine harvester





- New improved varieties with disease resistance and high yield
- Improvement in the seed supply of improved mung bean varieties

Break Through in Weed Management

Control of all types of weeds in mung bean through post-emergence application of herbicides

Before the use of herbicides

After the use of herbicides

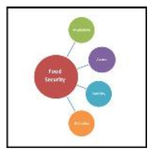
Mechanized Harvesting

- Use of chemical desiccant to dry the crop
- Adjustment in wheat combine to use for mung bean harvesting

Technology dissemination farmers' Field days

Importance of Pulses in Food Security

Dr. Irfan Ahmad Baig



Pakistan is one of the world's largest producers of the agricultural commodities

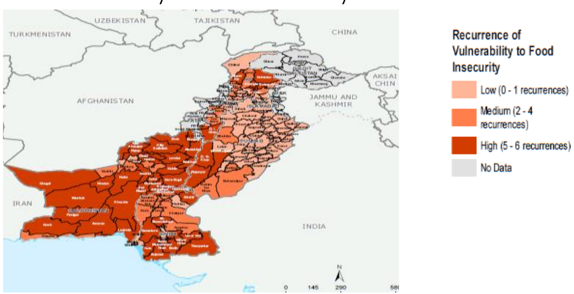
- **Apricot (6th)**
- **Buffalo Milk (2nd)**
- **Chickpea (3rd)**
- **Cotton, lint (4th)**
- **Cotton, Seed (3rd)**
- **Dates (5th)**
- **Mango (6th)**
- **Onion, dry (7th)**
- **Oranges (11th)**
- **Rice (12th)**
- **Sugarcane (5th)**
- **Peas (9th)**
- **Wheat (8th)**

Source: FAO Stat http://www.fao.org/faostat/en/#rankings/countries_by_commodity

Food Security or insecurity??

- Pakistan ranks 77th out of 109 on the Global Food Security Index
- Six out of 10 Pakistanis are food insecure.
- Food insecurity persists although food production is sufficient to feed all Pakistanis
- Almost half of women and children under five years of age are malnourished (WFP, 2017)
- 40% of cooked food is wasted (Dawn.com, 2016)

Vulnerability to Food Insecurity



"Pulses are important food crops for the food security of large proportions of populations, particularly in Latin America, Africa and Asia, where pulses are part of traditional diets and often grown by small farmers" (D.G FAO, 2016)

"Pulses can contribute significantly in addressing hunger, food security, malnutrition, environmental challenges and human health," (Ban Ki-moon)

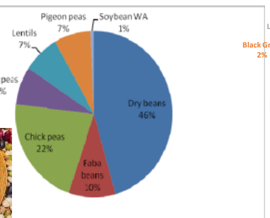
Pulses are important..................Why?

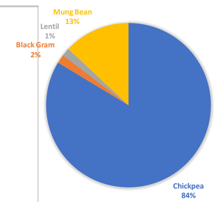
- Accessible
  - Sustainable in marginal environment
  - Long shelf life
- Affordable
  - Considered as cheap source
- Efficient
  - Low water requirement
  - Environmental friendly ....compared to Animal protein
- Sustainable
  - Climate resilient
  - Soil friendly
- Healthy
  - Rich in nutrition
  - Low in fats
- Low food wastage footprints

Economic importance of Pulses

- Pulses are cultivated on 5% of the total cropped area.
- Major pulse crops grown in the country are chickpea, lentil, mong bean, black gram
- Chickpea occupies 84% of the total pulses area with 71% contribution to the total production
- Mung bean occupies 13% of total area devoted to pulses contributing 25% to the total pulses production
- The black gram occupies 2 % and lentil 1 % of total area with each production share of 2%

Composition of Pulses area………Pak vs World



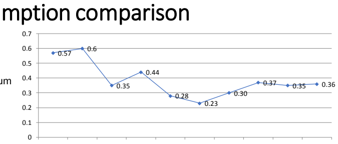


Pulses ………..Consumption comparison

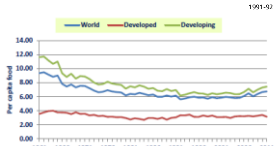
World Average: Around 6.96 Kg/capita/annum

Developing Countries: Around 7.80 Kg/capita/annum

Pakistan: 4.10 Around Kg/capita/annum

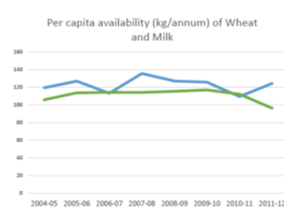


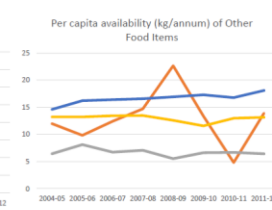
Pulses Consumption (Kg/Person/Month)



Commodity	Punjab 000 Tons	Pakistan 000 Tons	Ann. Per capita consumption (kg/head)
Chickpea	307.77	568.22	2.28
Lentil	62.30	115.02	0.60
Mung	87.22	161.03	0.84
Mash	37.38	69.01	0.36

Continued……

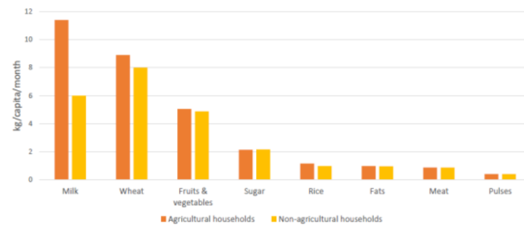




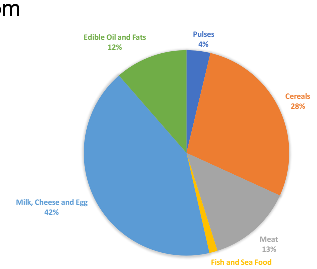
(Malik et. al., 2015)

Food Diversity.................A serious concern

Consumption Pattern..........pulses are last priority (Around 3-4 percent)

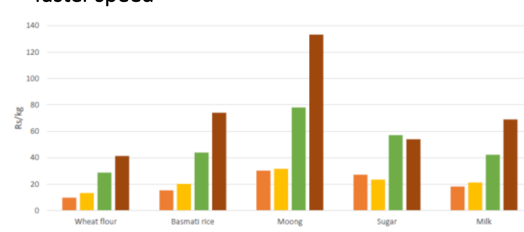


Share of Food Expenditure.........Pulses at the bottom

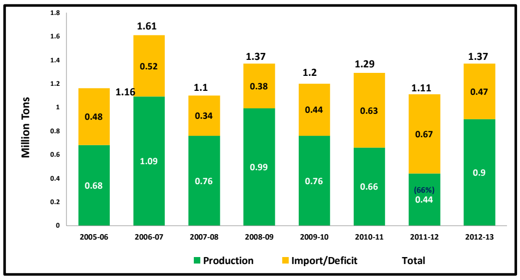


(HIES, 2016)

Price trends ....Pulses are escalating on a faster speed

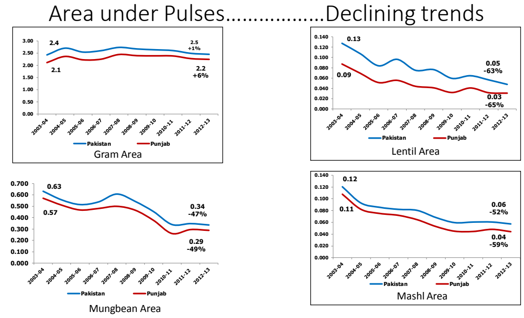


Overall national deficit in pulses

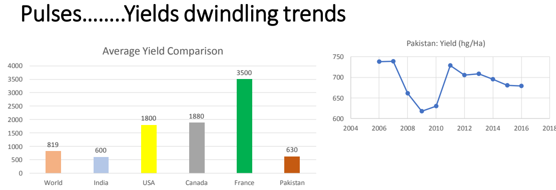


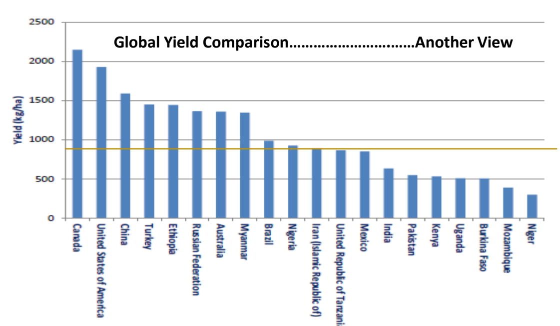
Source: Agri. Statistics of Pakistan, 2012-13

Area under Pulses.................Declining trends

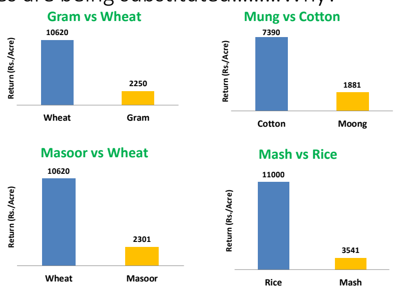


Pulses........Yields dwindling trends





Pulses are being substituted………Why?



Continued …..

Activities	Major Crops	Pulses
Competition with major crops in terms of preference	Wheat (Rabi)	Chickpea and lentil
	Rice and Cotton (Kharif)	Mung and mash
Chemical weedicides	Available	Not available
Heavy rains	Mostly beneficial	Damage crop
Frost impact	Little	Severe
Harvesting	Mechanical	Manual
Crop security	Generally secured	Risky
Post harvest losses	Little	Severe
Income	Definite	Not sure

What Should We Do?

- Promoting and sustaining consumption
- Supporting production
- Strengthening the value chain

Promoting and Sustaining Consumption

- Awareness: Health and nutritional benefits of pulses
- Procurement: Thru public intervention
- Investment: In product innovation
- Promotion: R&D for innovative recipes

Supporting Production

- Investment: R&D to improve productivity
- Investment: Breeding climate smart varieties
- Development: Seed systems that empower smallholders
- Cropping systems: Taking advantage of the beneficial impacts of pulses
- Market reforms: Stable incomes for farmers

Strengthening the Value Chain

- Networks: Pulse commodity associations and organizations
- Storage: warehouses and logistics
- Technology: Processing legumes
- Public intervention: Monitoring market intermediaries
- Commercialization

Area, Yield and Production of Pulses of Pakistan

Year	Area (ha)	Yield (hg/Ha)	Production (Tones)
2006	163800	7381	120900
2007	163200	7390	120600
2008	154800	6609	102300
2009	179400	6176	110800
2010	231700	6301	146000
2011	175800	7287	128100
2012	212000	7057	149600
2013	207000	7087	146700
2014	197100	6956	137100
2015	192452	6805	130958
2016	205399	6787	139397

(FAO STAT, 2017)

PULSES BREEDING IN PAKISTAN: Current Status and Future Needs

CH. MUHAMMAD RAFIQ
Director Pulses
Ayub Agri. Research Institute,
Faisalabad

PULSES ?

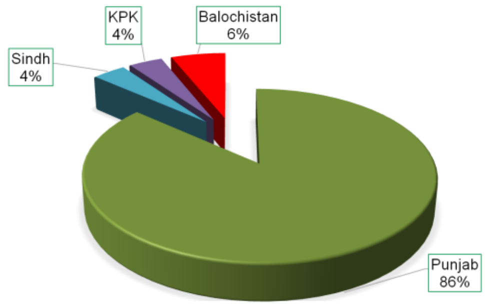
	Rabi Pulses	Kharif Pulses
Low Rainfall (213.0 mm)	Chickpea	Mungbean
High Rainfall (957.9 mm)	Lentil	Mashbean

Pulses Area and Production

CROP	AREA (000 Ha)		PRODUCTION (000 Tones)	
	Punjab	Pakistan	Punjab	Pakistan
Chickpea	**854.9**	945.0	**227.2**	312.0
Lentil	**11.3**	17.0	**4.0**	8.6
Mung	**133.1**	140.3	**93.9**	98.0
Mash	**12.7**	19.2	**4.9**	7.6

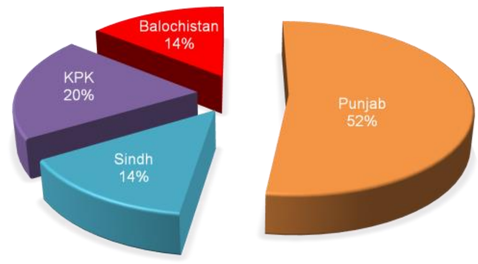
Source: Bureau of Statistics 2015-16, Pakistan

Share of Different Provinces in National Chickpea Production (Av. of last 5 years)



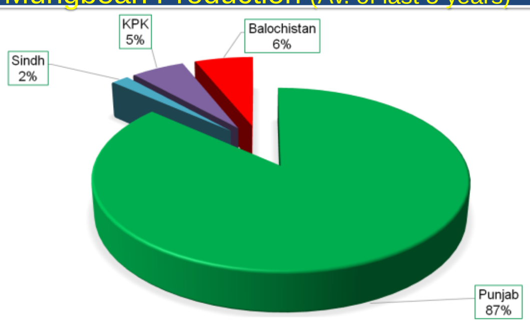
Source: Bureau of Statistics, Pakistan

Share of Different Provinces in National Lentil Production (Av. of last 5 years)



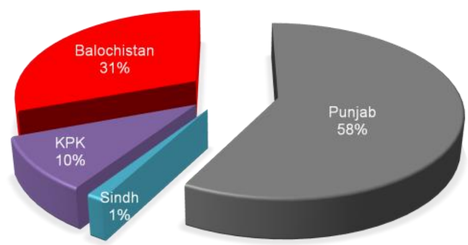
Source: Bureau of Statistics, Pakistan

Share of Different Provinces in National Mungbean Production (Av. of last 5 years)



Source: Bureau of Statistics, Pakistan

Share of Different Provinces in National Mashbean Production (Av. of last 5 years)



Source: Bureau of Statistics, Pakistan

Future Requirements in Pakistan

CROP	Current		Projected 2020		Projected 2025	
	Population (Millions)	Requirement (000 tones)	Population (Millions)	Requirement (000 tones)	Population (Millions)	Requirement (000 tones)
Chickpea	208	**474**	220	**502**	227	**518**
Lentil	208	**125**	220	**132**	227	**136**
Mung	208	**175**	220	**185**	227	**191**
Mash	208	**75**	220	**79**	227	**82**

Requirement based on consumption per capita (kg/annum)
Chickpea= 2.28; Lentil= 0.60; Mung= 0.84; Mash= 0.36

Bureau of Statistics

Gap in Production and Requirement of Pakistan

Crop	Current			Projected 2020			Projected 2025		
	Produ-ction (000 T)	Require-ment (000 T)	Gap (000 T)	Produ-ction (000 T)	Require-ment (000 T)	Gap (000 T)	Produ-ction (000 T)	Require-ment (000 T)	Gap (000 T)
Chick pea	312.0	**474**	-162.0	312.0	502	-190	312.0	518	-206.0
Lentil	8.6	**125**	-116.4	8.6	132	-123.4	8.6	136	-127.4
Mung	98.0	**175**	-77.0	98.0	185	-87	98.0	191	-93.0
Mash	7.6	**75**	-67.4	7.6	79	-71.4	7.6	82	-74.4

Institutes Working on Pulses

S. No.	Name of Institute
1	Pulses Research Institute (PRI), Faisalabad.
2	Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad.
3	Arid Zone Research Institute (AZRI), Bhakkar.
4	Barani Agricultural Research Institute (BARI), Chakwal.
5	Regional Agricultural Research Institute (RARI), Bahawalpur.
6	National Agriculture Research Centre, Islamabad.
7	Agriculture Research Institute, Mangora, Swat.
8	Nuclear Institute for Food and Agriculture, Tarnab, Peshawar.
9	Arid Zone Research Centre, DI Khan.
10	Agriculture Research Institute, Sariab, Quetta.
11	Agriculture Research Institute, Tandojam, Sindh.

Varieties Released in Pakistan

Crop	Varieties Released
Chickpea	40
Mungbean	24
Lentil	12
Mash	6
Drypeas	1
Mothbean	1

Breeding Thrust

- **CHICKPEA**
  - Drought, Cold, Heat, Blight, Wilt and Weeds
- **LENTIL**
  - Drought, Heat, Rust and Weeds
- **MUNGBEAN AND MASH**
  - Heat, Drought, Heavy Rains
  - Mungbean Yellow Mosaic Virus & Urdbean Leaf Crickle Virus
  - Insect pests
  - Weeds

General Issues

- Grown on marginal lands /poor soils
- Non-availability of quality seed
- Climate change- Erratic rainfall
- Slow dissemination of approved varieties
- Decrease in area
- Decline in production
- Change in cropping pattern
- Gap between national average yield and potential yield
- Low priority crops

Ways to Increase Pulses Production

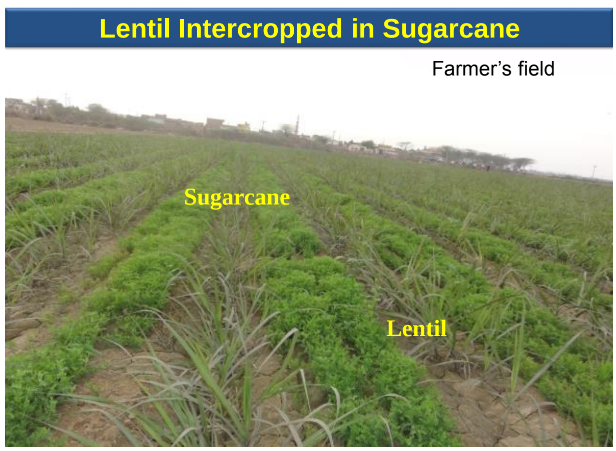
Increasing area under Pulses cultivation

- By Intercropping Pulses in Sugarcane
- By Growing Mung & Mash as Catch Crop between Wheat & Rice

Genetic improvement of pulses varieties to compete major crops in term of economic return

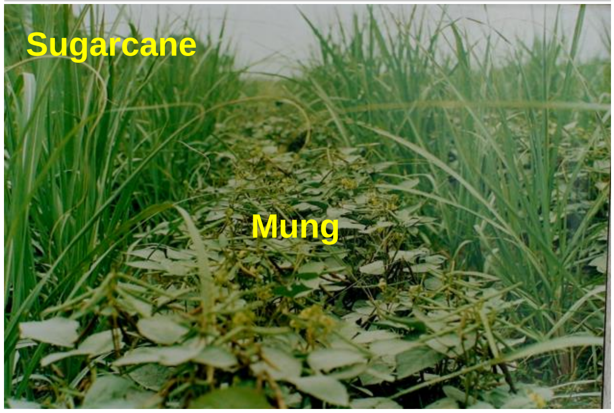
- Development of Pulses varieties with high biomass and high harvest index
- Suitable for intercropping and catch crop in major cropping systems
- Responsive to high inputs and high moisture level

Chickpea Crop in Thal Zone (Rainfed)


Lentil Intercropped in Sugarcane
Farmer's field
Sugarcane
Lentil

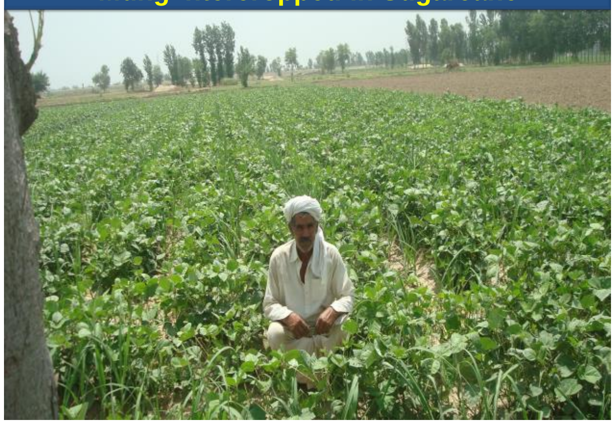
Lentil Intercropped in Sugarcane

Mung Intercropped in Sugarcane



Chickpea Intercropped in Sugarcane

Mung Intercropped in Sugarcane



Current Status of Breeding Pulses

- Creation of genetic variation
  - Introduction
  - Hybridization
    - Selection of parents
    - Crossing techniques
    - Handling of segregating populations
- Mutation
- Selection within that variation
- Evaluation of selected lines
- Marker assisted selection for disease tolerance in mungbean

Introduction of Genotypes

Introduction is generally facilitated by the following ways:

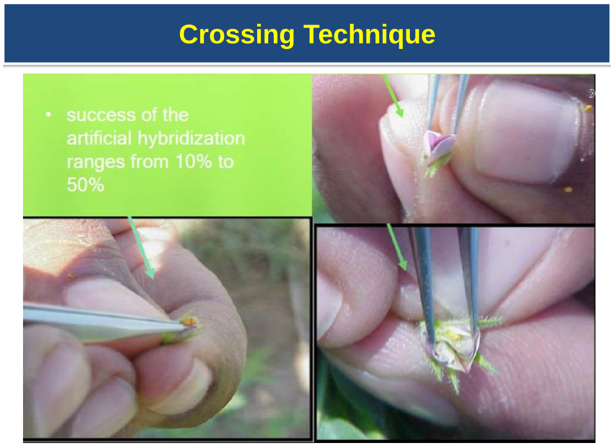
- Exchange of material with fellow plant breeders
- Exploration of areas showing rich variation of the species
- Obtaining genetic resources from international institutes / organizations

Hybridization

Combining desirable traits from two or more parents into a single cultivar.

Selection of Parents

- When the aim is to replace the existing variety with a superior one, the existing variety with adaptation to the local environment is a logical choice as one parent. The second parent must be so chosen that it complements the first parent.
- If creation of variation for the desired traits is the objective, then diverse parents are selected.



The success rate of artificial hybridization can be increased by:

- Selection of large flower buds
- Selection of lateral buds rather than the terminal ones
- Avoiding mechanical injury to the floral parts at the time of emasculation and pollination
- Attempting hybridization after the formation of the first pod.

- Under low temperature emasculation is done in the afternoon and pollination in the next morning .
- In case of high temperature followed by immediate pollination is recommended (in rabi pulses).
- SINGLE CROSS: Used to transfer resistance against biotic and abiotic stresses.

THREE WAY CROSSES: The progenies of three-way crosses are more variable with wide genetic base than single crosses.

MULTIPLE CROSSES: The cultivars developed from multiple crosses are expected to have wider adaptation for a range of environments.

Handling of Segregating Populations

Selection methods:

- **Pedigree method:** for selection for resistance to biotic stresses.
- **Bulk method:** used for the development of high yielding and short duration varieties.
- **Modified bulk method:** for selection of traits such as abiotic stresses, seed size, earliness and plant type.

Mutation Breeding

This technique is being practiced by Agricultural Organizations under PAEC, Islamabad for developing varieties;

- **Ionizing radiations**
  - Particulate radiation: alpha rays, beta rays, fast and thermal neutrons
    - Non-particulate radiation: x-rays, and gamma rays
    - Non-ionizing radiation: ultraviolet (UV) radiation
- **Chemical mutagens**

Future Needs / Strategies

Crop	Desired Improvement	Benefits
Chickpea	• Short duration /Earliness in maturity • Input responsive and disease tolerant genotypes • Refinement of production technology for irrigated areas	Chickpea popularization in irrigated areas.
Lentil	• High harvest index • Disease tolerant genotypes • Genotypes suitable for intercropping • Refinement of production technology	• Lentil popularization in irrigated areas • Increased area & production

Crop	Desired Improvement	Benefits
Mash	• Short duration varieties • Suitable genotypes for spring and kharif season • Zone specific genotypes • Climate smart production technology	• As catch crop in rice-wheat cropping system • Two crops (spring and kharif season) will become possible • Increase in area & production
Mung	• Short duration (60-65 days) varieties • Heat tolerant genotypes • Resistance against *Cercospora* Leaf spot disease • Climate smart production technology	• Increase reliability • Stability in production • As catch crop in rice-wheat cropping system

Steps to Boost Production

- Availability of quality seed to the farmers
- Mechanization of sowing and harvesting operations
- Popularizing the use of rhizobial culture
- Dissemination of improved production technology through electronic , print media and extension staff
- Training of scientists at International Organizations

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? ANY QUESTION **?**

?

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THANKS

Microbial inoculation for sustainable production of Legumes

Professor Dr. Zahir Ahmad Zahir
Institute of Soil & Environmental Sciences
University of Agriculture, Faisalabad

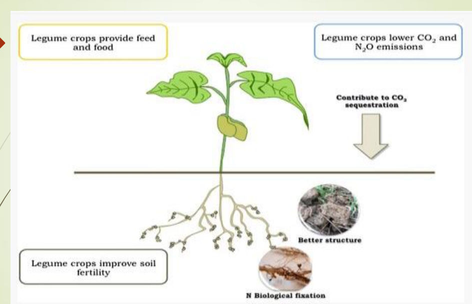
Importance of Legumes

- Legume crops could play an important role by delivering multiple services in line with sustainability principles:
  - By serving as fundamental, worldwide source of high-quality food and feed
  - Legumes contribute to reduce the emission of greenhouse gases, as they release **5–7 times less** GHG per unit area compared with other crops
  - Allow the sequestration of carbon in soils with values estimated from **7.21 g kg^{-1} DM**, **23.6** versus **21.8 g C kg^{-1} year**
  - Save fossil energy inputs in the system by N fertilizer reduction, corresponding to **277 kg ha^{-1} of CO_2 per year**

(Stagnari *et al.*, 2017)

- **Legumes perform well in conservation & intercropping systems, important in developing countries as well as in low-input and low-yield farming systems**
  - Legumes fix the atmospheric nitrogen
  - Improve soil quality by addition of organic matter through plant biomass
  - Facilitate soil nutrients' circulation and water retention
- Based on these multiple functions, legume crops have high potential for conservation agriculture, being functional either as growing crop or as crop residue

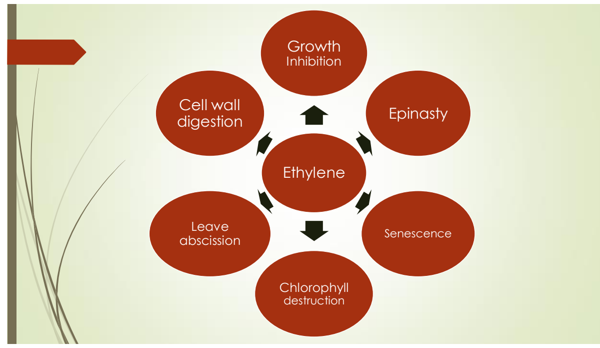
(Stagnari *et al.*, 2017)



(Stagnari *et al.*, 2017)

Challenges to Increase Productivity and Availability of Legumes

- Pulses production is mainly concentrated on marginal and/or rain-fed areas of Pakistan, which leads to poor growth, nodulation, and yield.
- Among different constraints contributing for their low productivity, elevated level of stress hormone i.e. ethylene in response to various biotic and abiotic stresses is considered as major one.
- Its negative role in the failure of legume-rhizobium symbioses is well known. (Shahroona et al., 2011)



Inhibition of Ethylene Action/Synthesis

Chemical Approaches

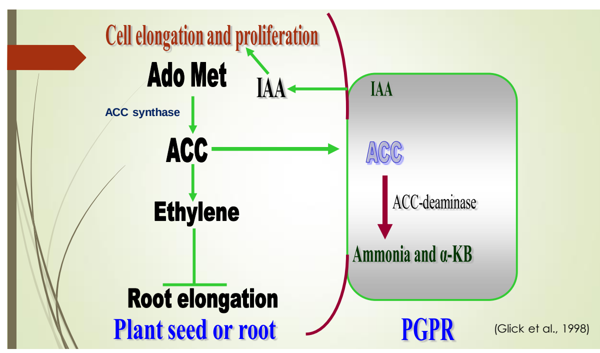
- Ag^{+}, inhibitor of ethylene action
- AVG (aminoethoxyvinyle glycine), ethylene synthesis inhibitor
- AOA (aminooxyacetic acid), ethylene synthesis inhibitor

(Guinel and Sloetjes, 2000)

Biological Approach

- Use of microbes with ACC-deaminase activity

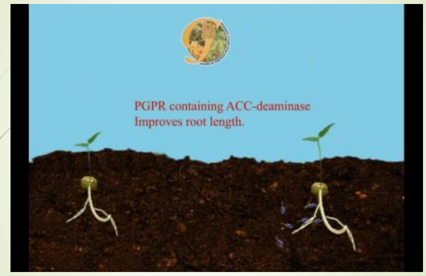
(Mayak et al., 1999)



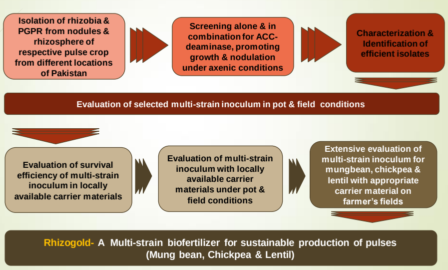
Co-inoculation with Rhizobia and PGPR containing ACC-deaminase

- Reduction in ethylene level
- Direct stimulation of rhizobial growth/survival in the soil
- Enlargement of the root system by hormone production for enhanced nutrient uptake and increase in the number of potential colonization sites by rhizobium
- Phosphate solubilization
- Pathogen suppression due to production of antibiotics

(Gull et al., 2004)



Roadmap



Collection of rhizosphere soil and nodules

Crop	Sites/Locations
Mung bean	**Faisalabad, Khanewal, Multan and Muzaffar Garh**
Chickpea	**Faisalabad, Jhang, Khushab, Bhakkar and Layyah**
Lentil	**Chakwal, Multan, Vehari, Bhakkar and Layyah**

Isolation of rhizobia and PGPR

Crop	PGPR (25 isolates of each crop)	Rhizobia (25 isolates of each crop)
Mung bean	F1, F2, F3, F4, F5, F6, F7, K1, K2, K3, K4, K5, K6, M1, M2, M3, M4, M5, M6, R1, R2, R3, R4, R5, R6	FS1, FS2, FS3, FS4, FS5, FS6, FS7, KH1, KH2, KH3, KH4, KH6, MN1, MN2, MN3, MN4, MN6, MG1, MG2, MG3, MG4, MG6
Chickpea	B1, B2, B3, B4, B5, FC1, FC2, FC3, FC4, FC5, J1, J2, J3, J4, J5, K1, K2, K3, K4, K5, L1, L2, L3, L4, L5	BK1, BK2, BK3, BK4, BK5, FSC1, FSC2, FSC3, FSC4, FSC5, JH1, JH2, JH3, JH4, JH5, KS1, KS2, KS3, KS4, KS5 , LY1, LY2, LY3, LY4, LY5
Lentil	LB1, LB2, LB3, LB4, LB5, LC1, LC2, LC3, LC4, LC5, LL1, LL2, LL3, LL4, LL5, LM1,LM2, LM3, LM4, LM5, LV1, LV2, LV3, LV4, LV5	LBR1, LBR2, LBR3, LBR4, LBR5, LCR1, LCR2, LCR3, LCR4, LCR5, LLR1, LLR2, LLR3, LLR4, LLR5, LMR1,LMR2, LMR3, LMR4, LMR5, LVR1, LVR2, LVR3, LVR4, LRV5

Measurement of ACC-deaminase activity

Crop	High [OD580> 0.75]	Medium [OD580: 0.50-0.75]	Low [OD580: <0.50]
Mung bean	F2,M2,K5,K6,F6, R4,R6	F1,F3,F4,F7, K1,K4,M1,R2, M4,M3,R5	F5,K2,K3,R3, M6,M5
Chickpea	B2,L5,J1,J3,L4, B5	B1,J4,J5,FC3 L3,K2,K3,K4, L2,K1	B3,B4,J2,FC1,FC2,L1,FC5, K5,FC4
Lentil	LM4,LV2,LL2, LC4,LC3,LB5, LB2	LB3,LC1,LC2, LM3,LV3,LV4, LV1	LB1,LB4,LC5, LL1,LL3,LL4, LL5,LV5,LM5, LM2,LM1

Screening of PGPR

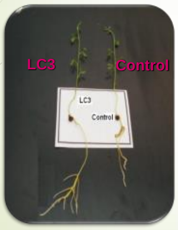
Screening of rhizobacteria for mung bean, chickpea and lentil under axenic conditions

- Isolates: 25 of each crop
- Replications : 3
- Design: CRD
- Nutrient solution: Hoagland solution (1/2 strength)
- Duration : 21 days

PGPR

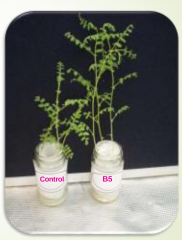
Lentil	LB5, LC3, LC4, LM4, LV2
Mung bean	F2, F6, M2, K6, R6
Chickpea	F2, F6, M2, K6, R6

PGPR-Lentil



PGPR-Mung bean

PGPR-Chickpea



Screening of rhizobia

Screening of rhizobia for mung bean, chickpea and lentil under axenic conditions

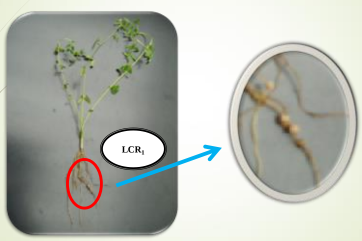
- Isolates: 25 of each crop
- Replications : 3
- Design: CRD
- Nutrient solution : Nitrogen-free Hoagland solution (1/2 strength)
- Duration : 50 days

Rhizobium

Lentil	LLR3, LBR2, LCR1, LMR3 LVR2
Mung bean	MG6, MN6, KH6, FS2 MN3
Chickpea	BK2, BK4, KS1, JH4, LY4

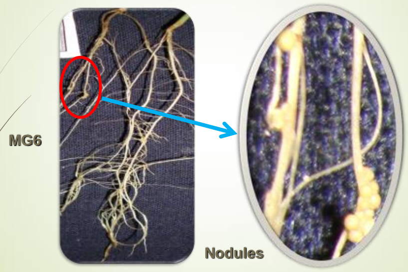
Rhizobium-Lentil

Rhizobium-Lentil

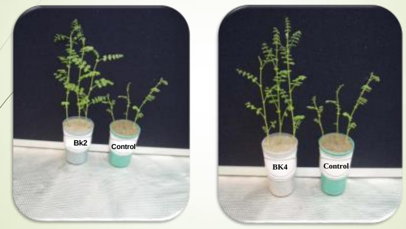


Rhizobium-Mung bean

Rhizobium-Mung bean



Rhizobium-Chickpea



Screening of effective combinations of rhizobia and PGPR under axenic condition

Rhizobial Isolates: 5 isolates for each crop

PGPR Isolates: 5 isolates for each crop

Replications : 3

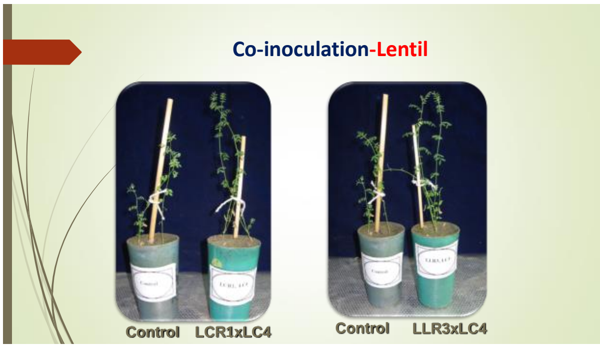
Design: CRD- Factorial

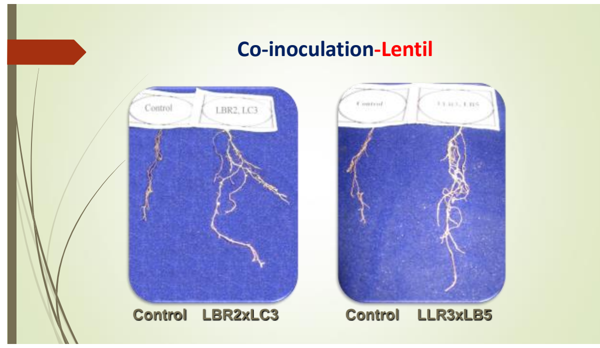
Nutrient solution: Hoagland solution (1/2 strength)

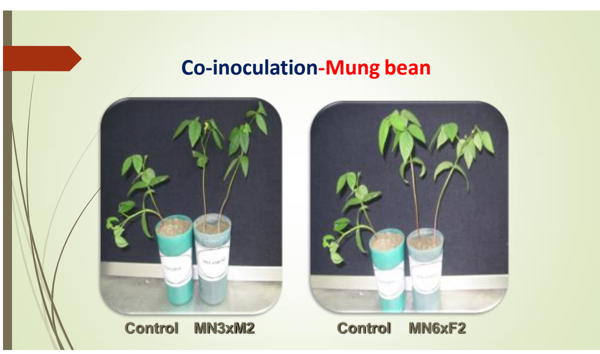
Duration: 50 days

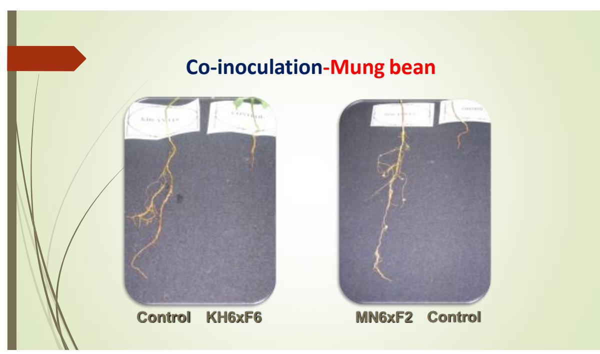
Combinations

Lentil	LLR3xLB5, LBR2xLC3, LCR1xLC4
Mung bean	MN6xF2, KH6xF6, MG6xF6
Chickpea	BK4xJ1, BK2xB5, JH4xJ1


Co-inoculation-Lentil
Control LCR1xLC4
Control LLR3xLC4


Co-inoculation-Lentil
Control
LBR2, LC3
Control LBR2xLC3
Control LLR3xLB5


Co-inoculation-Mung bean
Control MN3xM2
Control MN6xF2


Co-inoculation-Mung bean
Control KH6xF6
MN6xF2 Control

Co-inoculation-Chickpea

Control BK4xB2

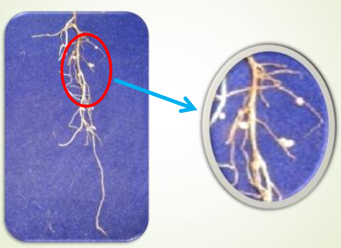
Control BK4xJ1

Co-inoculation-Chickpea

Control BK2xL4

Control JH4xJ1

Co-inoculation-Chickpea



BK2xB5 Nodules

CLASSICAL "TRIPLE" RESPONSE

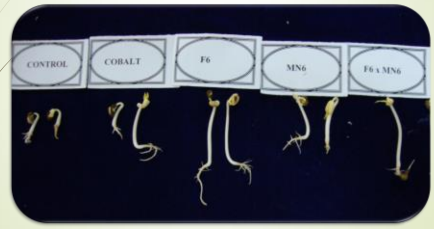
Classical triple response is a reliable marker to study the effect of ethylene on plant growth.

Response demonstrating

- **Inhibition of stem elongation**
- **Swelling of stem**
- **Changes in the direction of growth**

Effect of co-inoculation on classical “triple” response in lentil

Effect of co-inoculation on classical “triple” response in mung bean



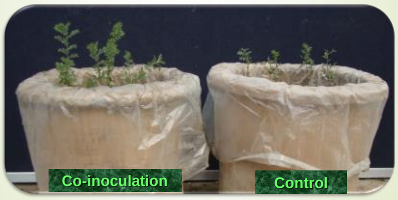
Effect of co-inoculation on classical “triple” response in chickpea

POT TRIAL

- Strains from three selected effective combinations of PGPR containing ACC-deaminase and rhizobia along with possible combinations were evaluated for their potential to improve growth and yield of lentil

- Location: Wire house of ISES, UAF
- Rhizobial strains: 3
- PGPR strains : 3
- Replications : 6
- NPK fertilizer : 20:60:25 kg ha^{-1}

Effect of co-inoculation on plant growth of lentil



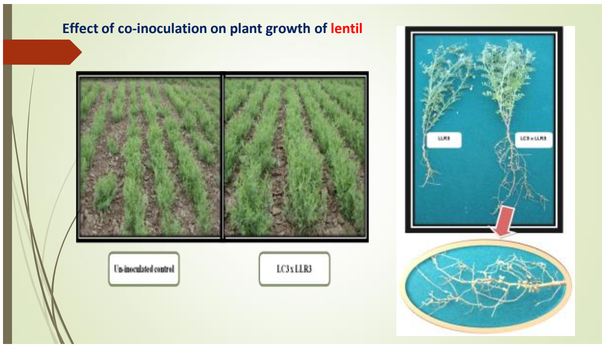
Effect of co-inoculation on mung bean in pot trial

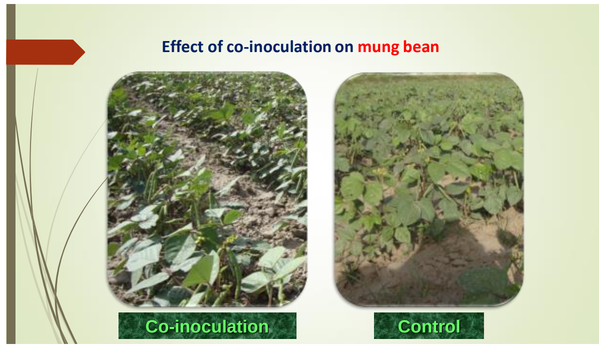
Effect of co-inoculation on plant growth of chickpea

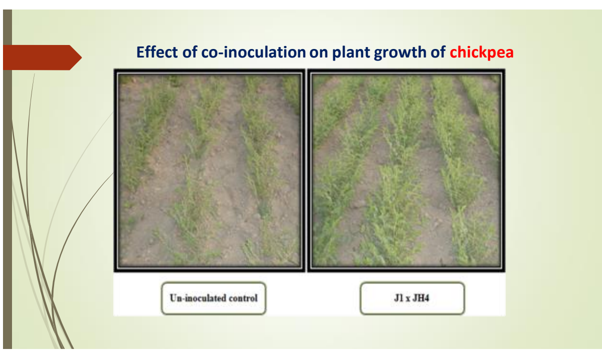
FIELD TRIALS

Field trials were conducted at 2 locations to further confirm the results of pot experiment.

- Rhizobial strains : 3
- PGPR strains : 3
- Locations : 2
  - Site I, Haroonabad
  - Site II & Site III, Univ. Agric., Fsd
- Replications : 3
- Design: RCBD
- Sowing method: Line sowing
- NPK fertilizer: 20:60:25 kg ha^{-1}


Effect of co-inoculation on plant growth of lentil
Un-inoculated control
LC3 x LLR3


Effect of co-inoculation on mung bean
Co-inoculation
Control


Effect of co-inoculation on plant growth of chickpea
Un-inoculated control
J1 x JH4


PGPR
Co-inoculation
Un-inoculated Control
Rhizobium

Mung bean strains

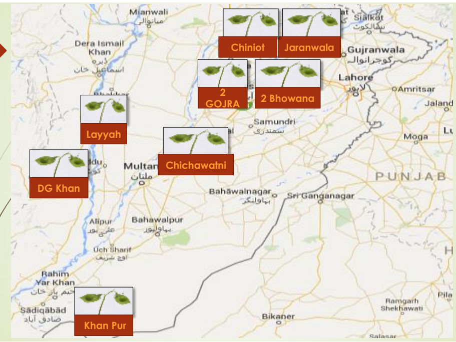
Code	Strain
F2	*Pseudomonas syringae*
F6	*Pseudomonas fluorescens biotype G*
MN6	*Rhizobium phaseoli*
MG6	*Rhizobium phaseoli*
KH6	*Rhizobium phaseoli*

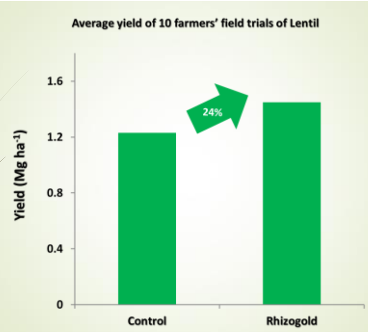
Chickpea strains

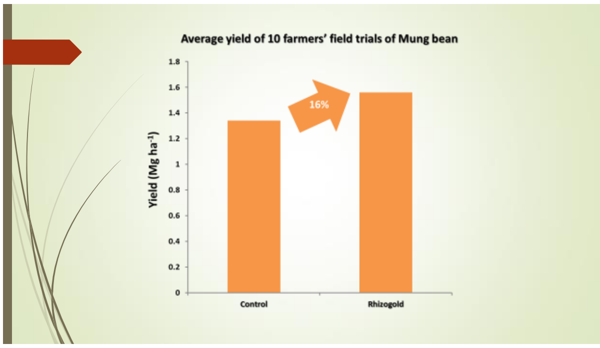
Code	Strain
J1	*Vibrios diazotrophicus*
B5	*Chrysobacterium gleum*
Bk2	*Mesorhizobium ciceri*
Bk4	*Mesorhizobium ciceri*
JH4	*Mesorhizobium ciceri*

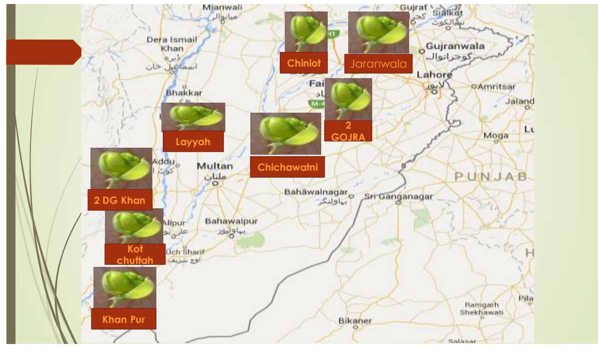
Lentil strains

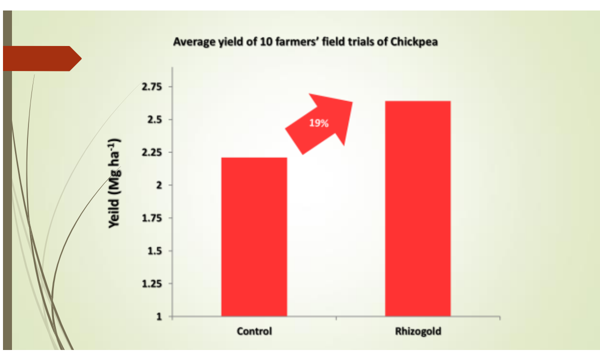
Code	Strain
LB5	*Pseudomonas bathycetes*
LC3	*Vibrios vulnificus*
LC4	*Flavobacterium ferrugineus*
LBR2	*Rhizobium leguminosarum*
LCR1	*Rhizobium leguminosarum*
LCR3	*Rhizobium leguminosarum*











Conclusion

- Microbial inoculation is an effective tool for **sustainable** production of legumes
- Application of ***Rhizobium*** significantly improved, nodulation efficiency of legumes
- Application of **PGPR** enhanced growth and yield of legumes through various mechanisms
- Co-inoculation of ***Rhizobium*** and PGPR possessing **ACC-deaminase activity** is more efficient in improving nodulation, growth and yield of legumes

Areas under Fine tuning

- Endophytes + Mesorhizobium in chickpea under drought
- Endophytes with carbonic anhydrase in cereals under moisture stress
- Allelopathic bacteria
- Rhizobium inoculation of cereals under saline condition for following legume crop
- Substrate dependent microbial production of auxins for soybean production

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- GIZ, World Vegetable Center

World Vegetable Center

Grand Challenges Canada

Thank You