

Wheat Breeding at ICARDA: Strategies, Achievements and Prospects

W. Tadesse, M. Sanchez-Garcia, S. Tawkaz, S. El-Hanafi, A. Sherif , I. Tahir, M. El-Bouhssini, K. Nazari, R. Sharma, Z. Bishaw, A. Niane, S. Assefa, H. Halila, A. Amri and M. Baum

Rabat, Morocco

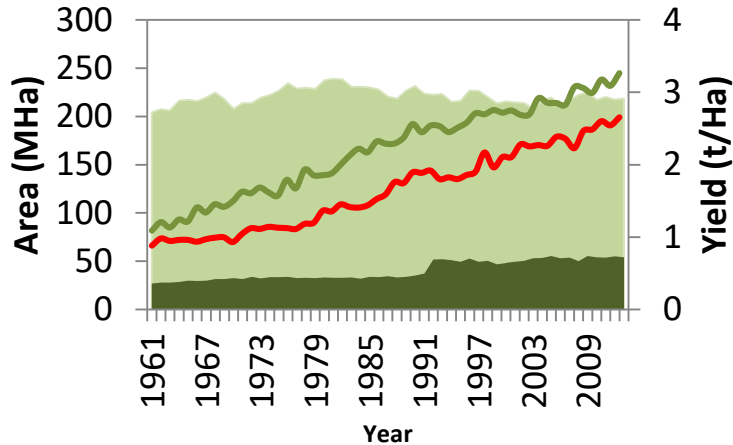
13th IWGS, 23-28 April, 2017
Tulln, Austria

ICARDA

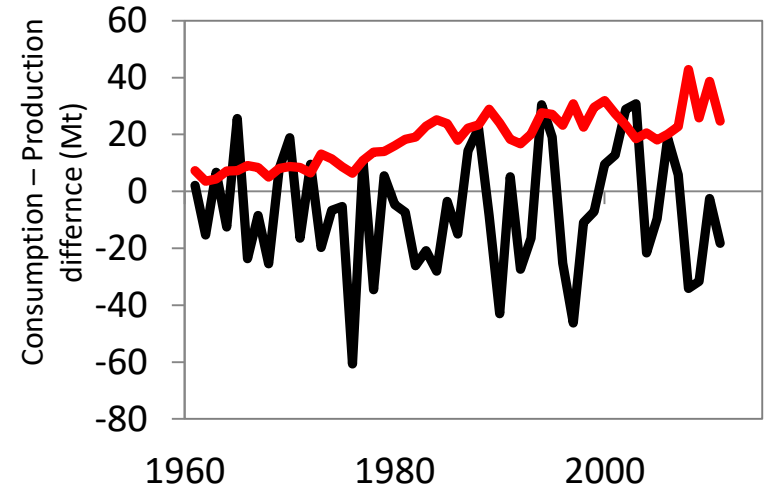
Rabat office, Morocco



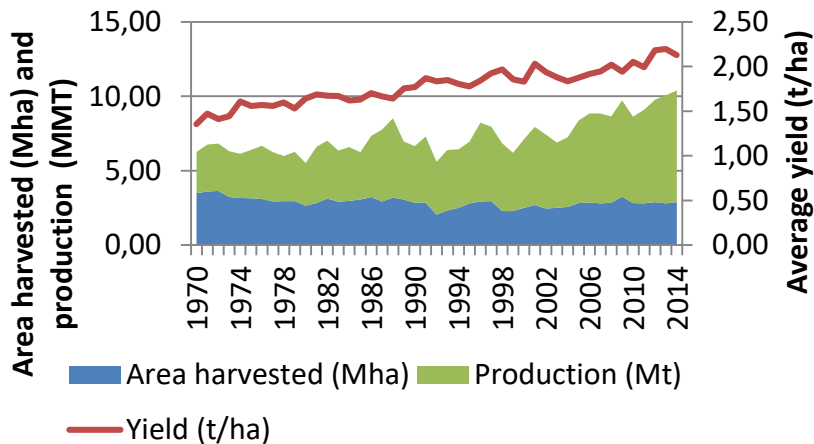
Target regions: CWANA + SSA



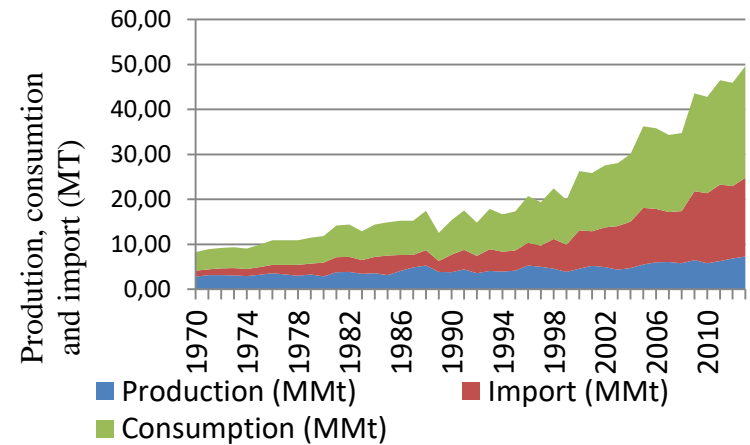
■ World Area ■ CWANA Area
— World Yield — CWANA Yield



— World — CWANA



■ Area harvested (Mha) ■ Production (Mt)
— Yield (t/ha)



■ Production (MMT) ■ Import (MMT)
■ Consumption (MMT)

17MT; 6 B\$

Major production constraints

Abiotic stresses


- Drought
- Heat
- Cold
- Salinity
- Pre-harvest sprouting
- Water lodging

Biotic stresses

- Yellow rust
- Stem rust
- Leaf rust
- Fusarium
- Septoria
- Tan spot
- Common bunt
- Root rots
- Hessian Fly
- Russian Wheat Aphid
- Sunn Pest

Wheat Breeding at ICARDA


Objectives



- High yield potential and broad adaptation



- Resistance to major diseases and insects



- **Drought, heat**, cold and salinity tolerance



- Grain quality



- Capacity building of NARS through training

Strategies and approaches




- Classification and targeting major MEs



- Shuttle breeding



- Marker assisted selection



- Use of wide crosses (Synthetics)

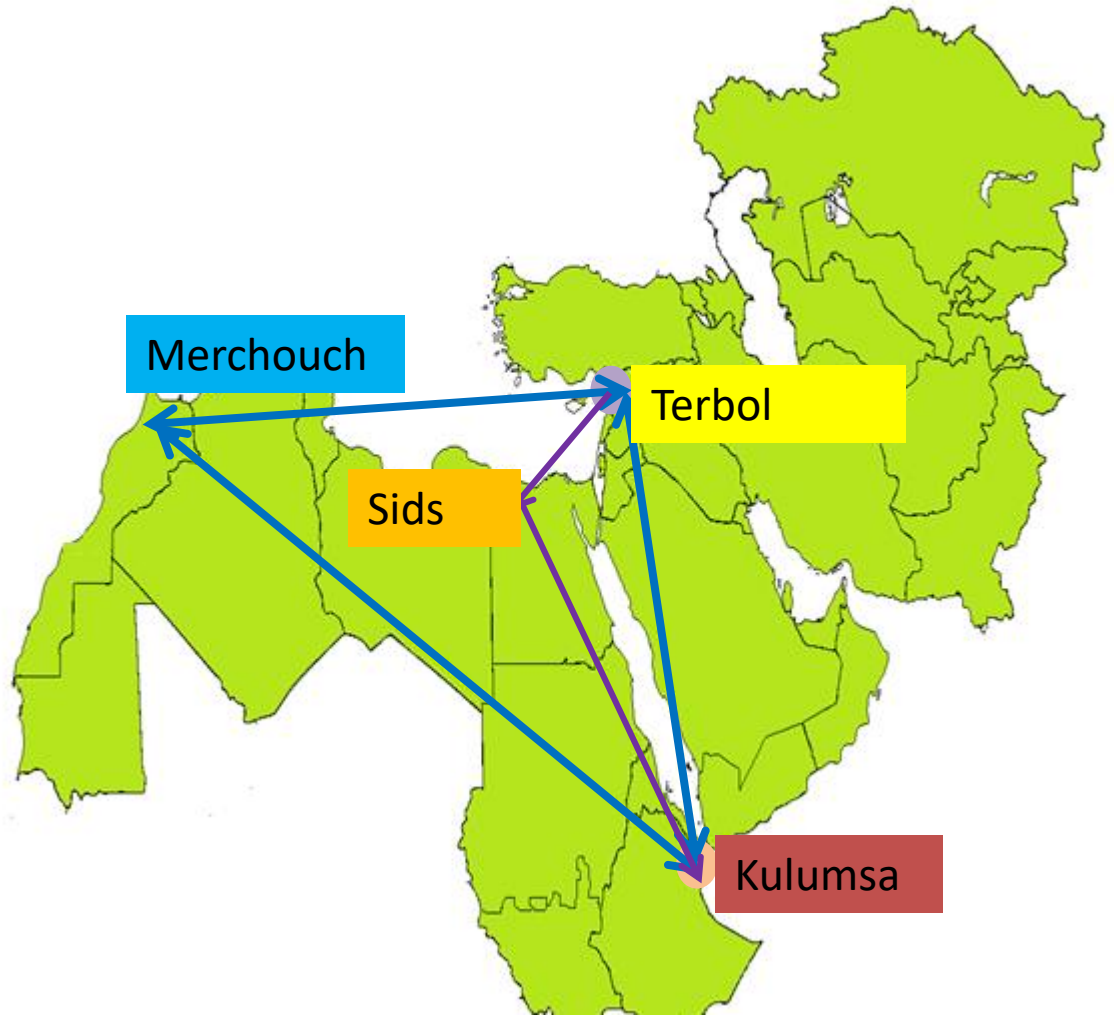
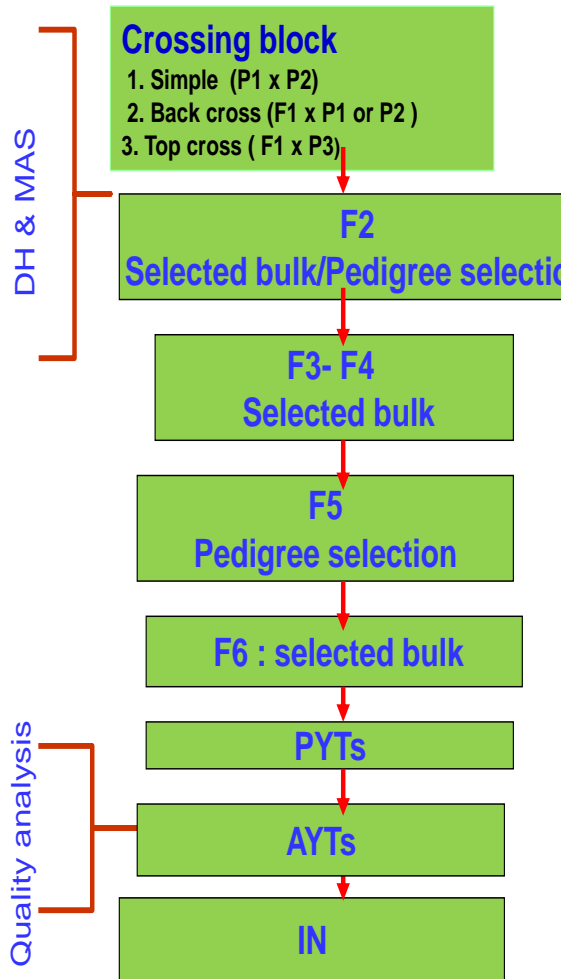


- Hot spots for disease screening



- Multi-location testing

Breeding Methods and Germplasm Flow



Key Locations

Marchouch + Jemaat Shaim: Yellow rust, Septoria, drought tolerance, HF resistance

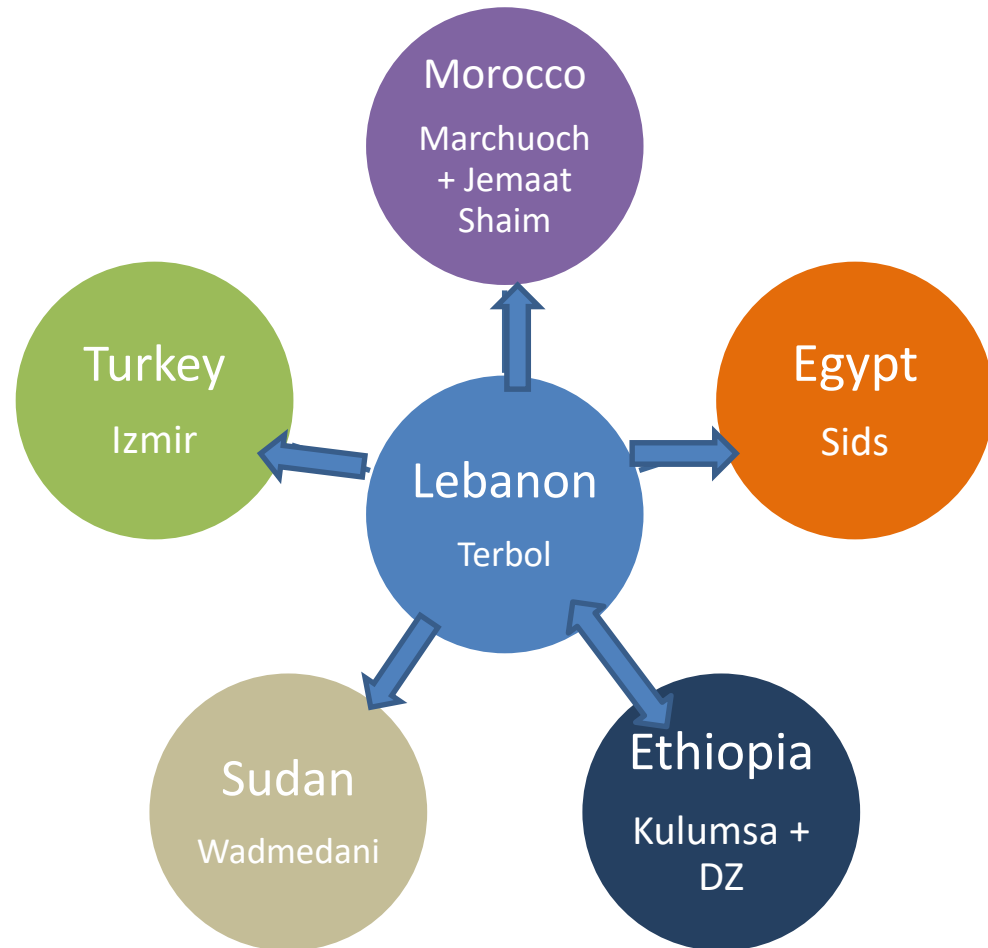
Sids: Yield potential

Izmir: Screening for rusts (Lab +field)

Kulumsa /Dz: Stem rust, yellow rust, septoria, fusarium

Wadmedani: Heat tolerance

Terbol: CB, adaptation, yield potential, rusts, cold, drought (at Kheferdan)



Crosses

- More than 3000 simple and top crosses
- About 100 interspecific crosses (durum x bread wheat)

Evaluation of segregating generations

- Terbol-Sids-Kulumsa-Merchuch/Terbol shuttle

Production of doubled haploids (DH)

- 1500-2000 DH lines

Yield trials:

PYTs (2000), 1st year and 2nd year AYT_s across key locations

Genotyping:

AYT_s have been genotyped using 15 K SNP

Quality analysis

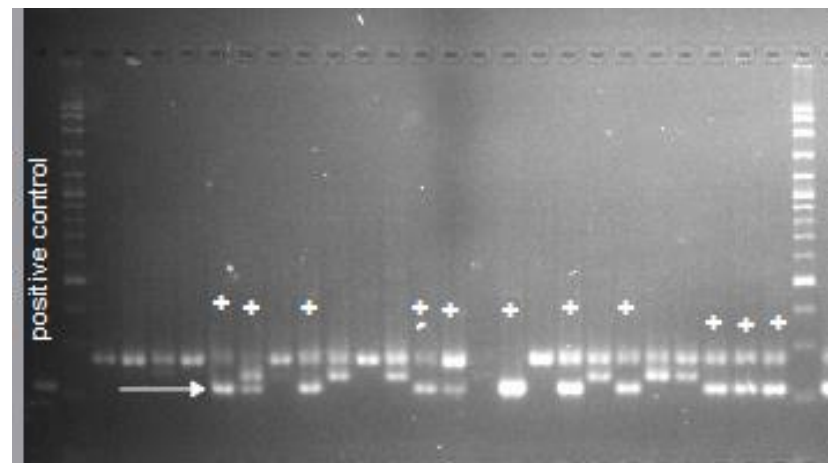
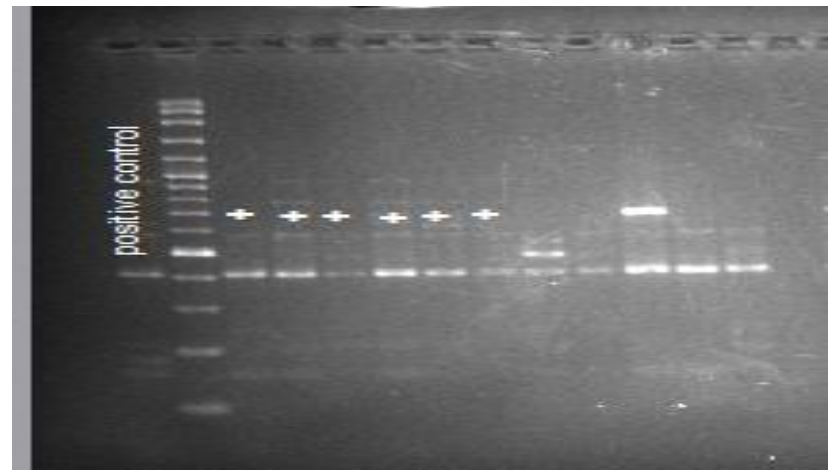
- NIR , Alveograph, Pharinograph

Composing and distribution of International nurseries



Gene Pyramiding: MAS

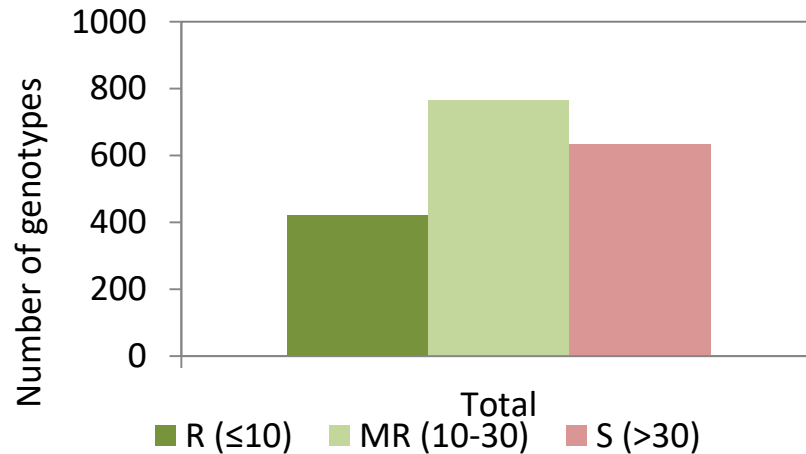
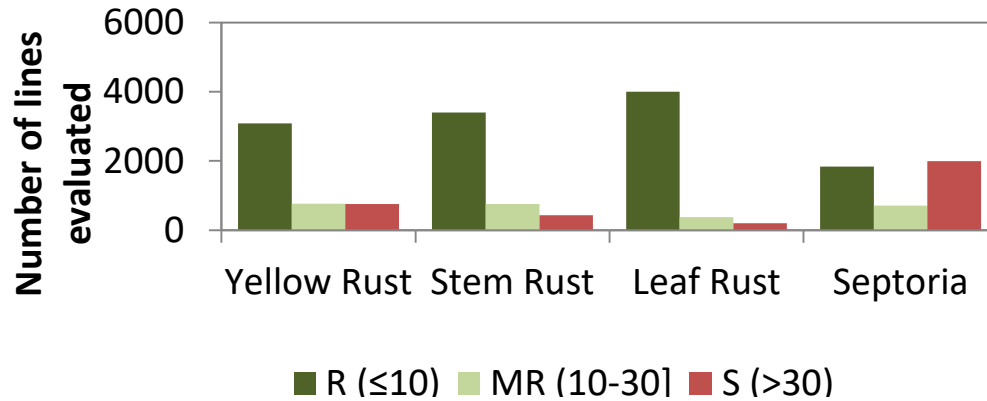
Stem rust	Yellow rust	Leaf rust	Other Genes
<i>Pavon Sr 24+ Sr 31+Sr 50</i>	<i>Yr5, Yr45</i>	<i>Lr37</i>	<i>Stb4,</i>
<i>Sr 50+Sr 45 # 1</i>	<i>Yr10</i>	<i>Lr34</i>	<i>Tsn1</i>
<i>Sr 25</i>	<i>Yr15</i>	<i>Lr67</i>	<i>Cre1</i>
<i>Pavon Sr 24+ SR 26+Sr 31</i>	<i>Yr17</i>	<i>Lr10</i>	<i>Cre8</i>
<i>Sr 22/CO 1213</i>	<i>Yr 48</i>	<i>Lr14a</i>	<i>Fhb1</i>
<i>Westonia Sr 24+ Sr 26</i>	<i>Yr 5+10</i>	<i>Lr24</i>	<i>H5, H13, H22</i>
<i>Sr 33+Sr 45 #36</i>	<i>Yr5+10+15</i>	<i>Lr23</i>	<i>H23, H26</i>
<i>Angas Sr 32</i>	<i>Yr48+Yr15</i>	<i>Lr22a</i>	
<i>Sr 2</i>	<i>Yr17+Yr48</i>	<i>Lr25</i>	
<i>Sr 38</i>	<i>Yr27+5+10+15</i>	<i>Lr24+Sr24</i>	
<i>Sr 39</i>	<i>Yr36</i>	<i>Lr19+Sr24</i>	
other minor genes	other miner genes		



Genetic stocks from Dr Evans Lagudah

Resistance to Diseases

Response of 4600 ICARDA's spring bread wheat genotypes to rusts and septoria at Kulumsa (above) and at Merchouch (below)

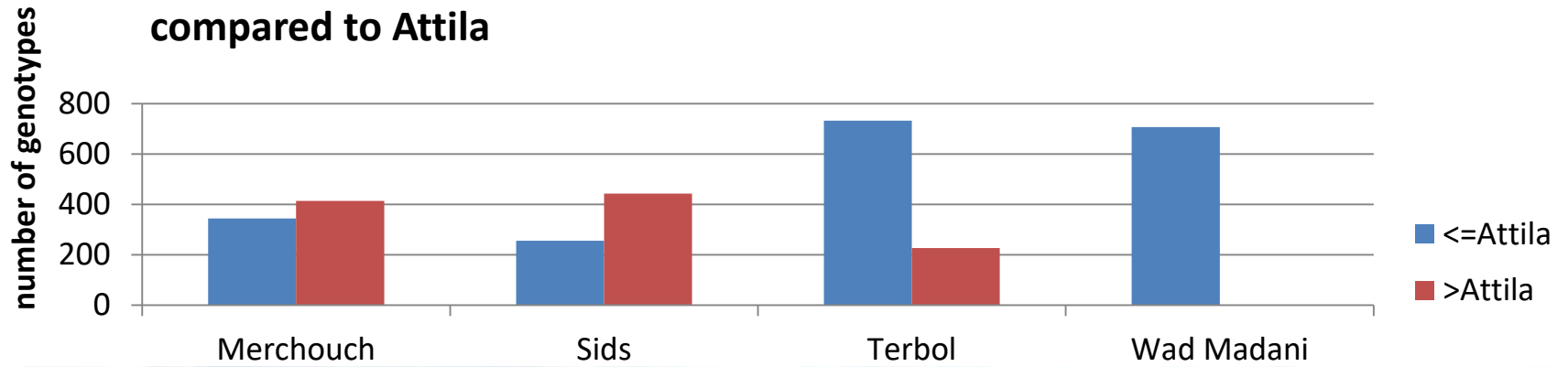


Synthetic derived wheat genotypes and their performance

Name	Days to heading	Plant height (cm)	Yellow rust severity	1000 seed weight (gm0)	Yield (t/ha)
NEJMAH-11	108	90	10MR	44	8.2
NEJMAH-8	108	85	10MR	43	7.4
NEJMAH-12	108	85	15MR	45	7.1
TAJ-1	107	100	40S	42	7.1
SHIHAB-8	109	95	5R	50	7.1
NEJMAH-19	109	85	10MR	45	6.9
MUNIA//CHEN/ALTAR 84/3/CHEN/AEGILOPS SQUARROSA (TAUS)//BCN	103				
		100	5R	46	6.7
SHIHAB-4	109	100	5R	55	6.7
SHIHAB-20	109	90	10MR	43	6.7
NEJMAH-17	108	90	5R	42	6.6
NEJMAH-20	108	90	10MR	44	6.6
NEJMAH-21	107	100	10MR	42	6.6
BEDER-5	107	90	10MR	39	6.6
SHIHAB-13	108	100	20MS	48	6.4
SHIHAB-19	108	100	5R	46	6.3
NEJMAH-6	108	85	5R	44	6.3
	107				
CROC-1/AE.SQUARROSA (205)//KAUZ/3/SASIA		85	5R	41	6.1
SHAMIEKH-1	110	95	5R	44	6.1
NEJMAH-26	108	90	5R	45	6.1
NEJMAH-18	114	90	5R	47	6.1
QAMAR-4	107	95	5R	39	6.0
Attila-7 (check)	108	95	5R	38	4.8



Variability of advanced wheat genotypes for heading date as compared to Attila



Mean grain yield level (t/ha) of selected elite SBW genotypes at Sids, Egypt

NAME	YR response at Merchouch	Yield (t/ha)
ATTILA/3*BCN//FLAG-2	20MR	11.1
FLAG-3/ICARDA-SRRL-5	10MR	10.6
FLAG-6/ICARDA-SRRL-6	15MR	10.3
SERI 82/SHUHA'S'//GRU90-204782/3/MUNIA/CHTO//MILAN	50S	10.19
KAUZ'S'/SERI/4/CHEN/AEGILOPS SQUARROSA (TAUS)//FCT/3/STAR	30S	10.0
KATILA-15//MNCH/3*BCN	30S	9.9
SERI 82/SHUHA'S'//GRU90-204782/3/MUNIA/CHTO//MILAN	50S	9.9
SERI.1B*2/3/KAUZ*2/BOW//KAUZ/4/KAUZ/FLORKWA-1	20MR	9.8
KAUZ'S'/SERI/4/CHEN/AEGILOPS SQUARROSA (TAUS)//FCT/3/STAR	70S	9.8
KAUZ'S'/SERI/3/KAUZ//KAUZ/STAR	70S	9.6
ATTILA 50Y//ATTILA/BCN/3/STAR*3/MUSK-3	40S	9.6
DEBEIRA/4/KAUZ//ALTAR 84/AOS/3/KAUZ	40S	9.5
KASYON/GENARO 81//TEVEE-1/.../4/CHEN/AEGILOPS SQUARROSA (TAUS)//BCN/3/KAUZ	20MR	9.5
DEBEIRA/4/KAUZ//ALTAR 84/AOS/3/KAUZ	40S	9.5
KAUZ/AA//KAUZ/3/KAPSW/SHUHA-17	30S	9.4
BOUSHODA-1/4/SHUHA-2/3/BOW'S'/NKT'S'//TEVEE'S'	30S	9.4
KAUZ//MON/CROW?S?/4/SERI.1B//KAUZ/HEVO/3/AMAD	20MR	9.4
ATTILA 50Y//ATTILA/BCN/3/STAR*3/MUSK-3	50S	9.3
KAUZ//MON/CROW?S?/3/VEE/PJN//2*KAUZ	30S	9.3
DEBIRA	50S	9.3
MISR-1	50S	9.7
SIDS-12	70S	9.3

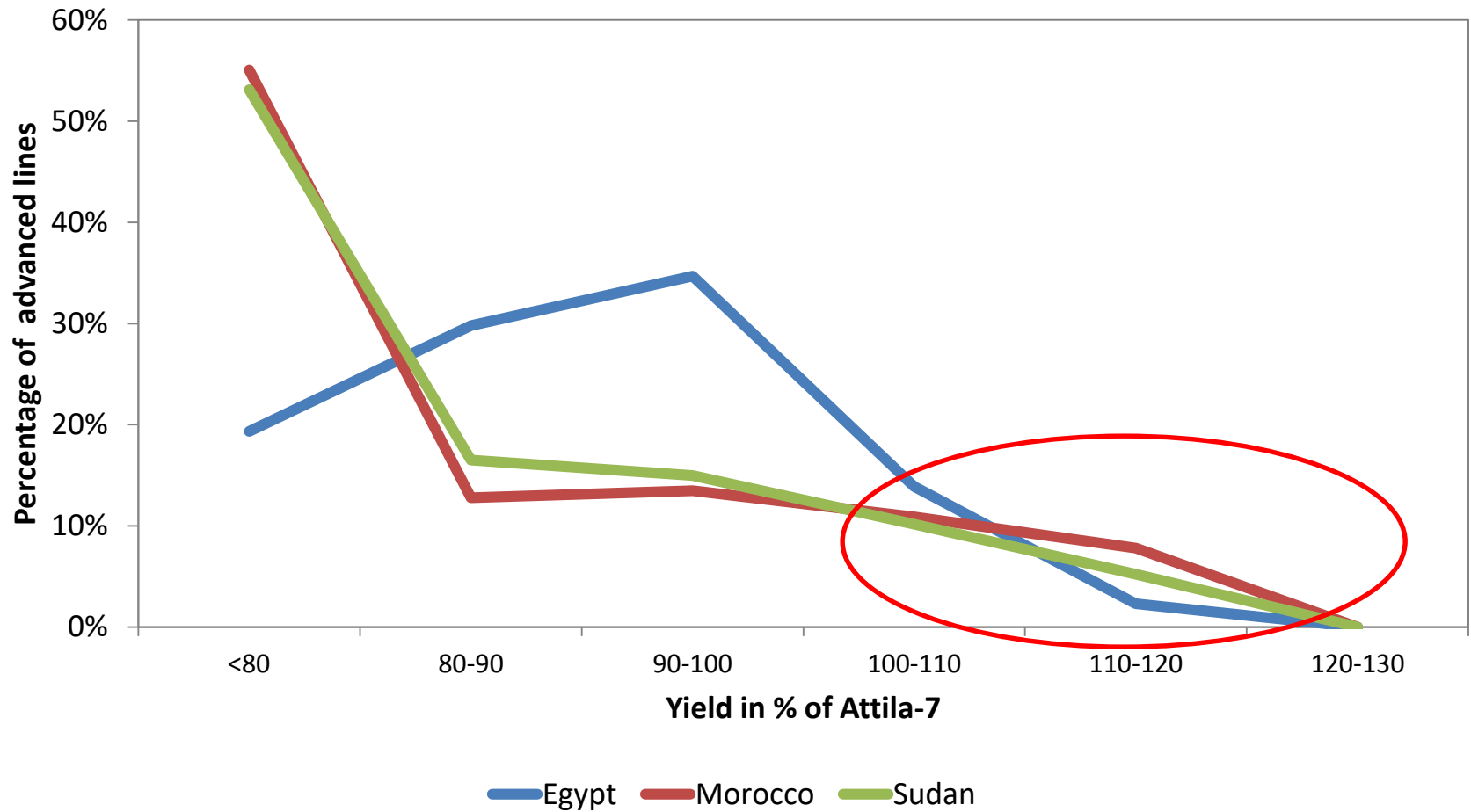


Performance of the top 10 bread wheat genotypes at Merchouch compared to Arehane (N. check)

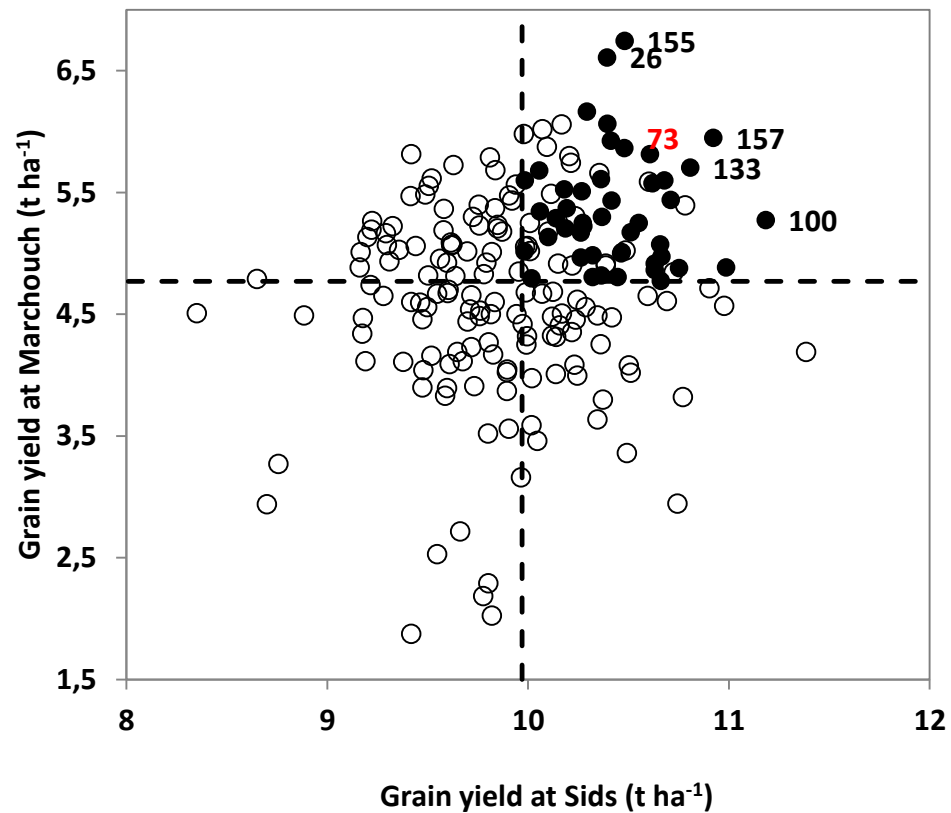
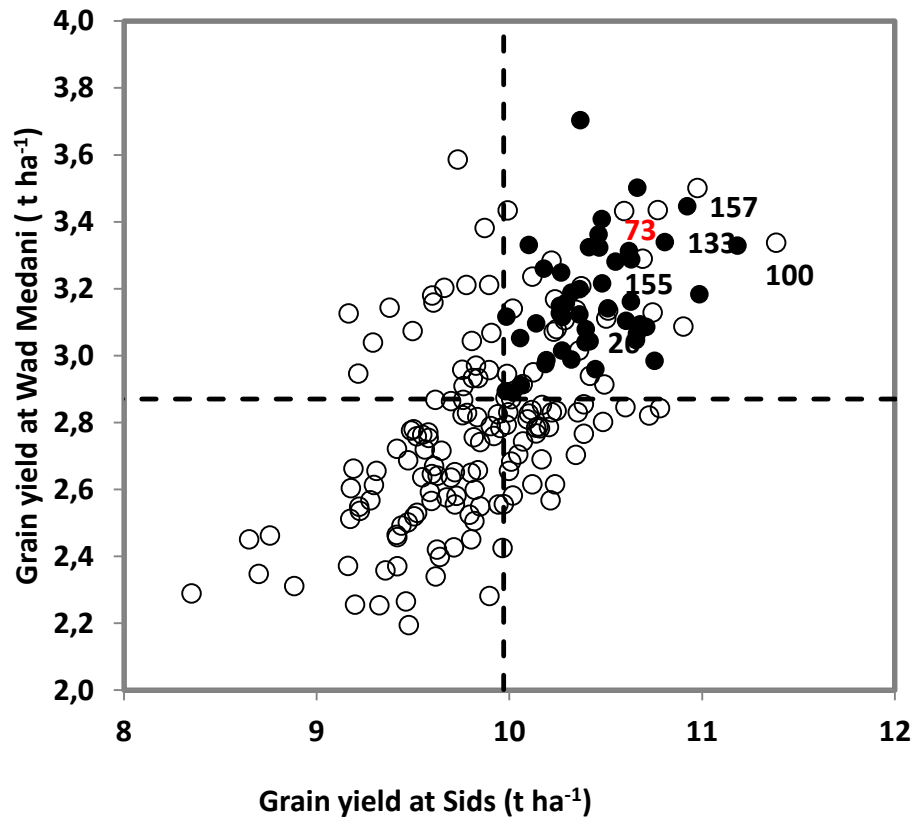
Var No.	Pedigree	Yield (T/ha)	Yield in % of Arehan
1004	KAUZ//MON/CROW'S'/3/SHUHA-4//NS732/HER/4/MILAN/PASTOR	7.50	195.8
1038	JAWAHIR-1/GIRWILL-5	6.16	160.8
1002	SHUHA-4//NS732/HER/3/MILAN/DUCULA	6.12	159.8
1027	SERI.1B*2/3/KAUZ*2/BOW//KAUZ/4/TRAP#1/BOW//PFAU/3/MILAN	5.71	149.0
1013	FLAG-3/ICARDA-SRRL-5	5.62	146.7
1028	KAUZ//ALTAR 84/AOS/3/MILAN/DUCULA	5.58	145.6
1014	ATTILA 50Y//ATTILA/BCN/3/PFAU/MILAN	5.56	145.2
1015	KAUZ//MON/CROW'S'/3/VEE/PJN//2*KAUZ	5.52	144.1
1037	SERI.1B//KAUZ/HEVO/3/AMAD/4/FLAG-2	5.42	141.4
1001	SERI.1B//KAUZ/HEVO/3/AMAD/4/FLAG-2	5.16	134.6
1016	SERI.1B//KAUZ/HEVO/3/AMAD/4/ATTILA//PSN/BOW/3/ATTILA/5/KAUZ'S'/SHUHA-15	5.15	134.4
1040	Arrehane	3.83	100.0



Relative grain yield performance of 825 wheat genotypes across key locations, 2015



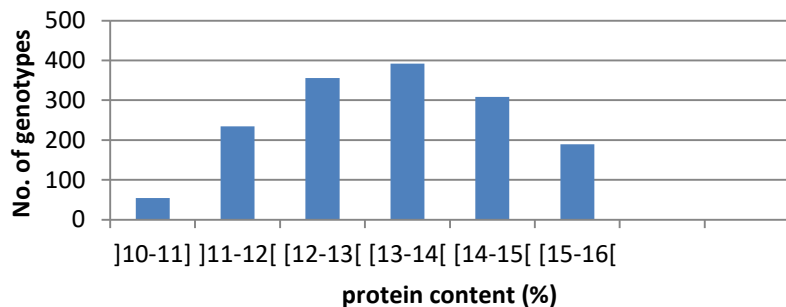
Yield of wheat genotypes across key locations



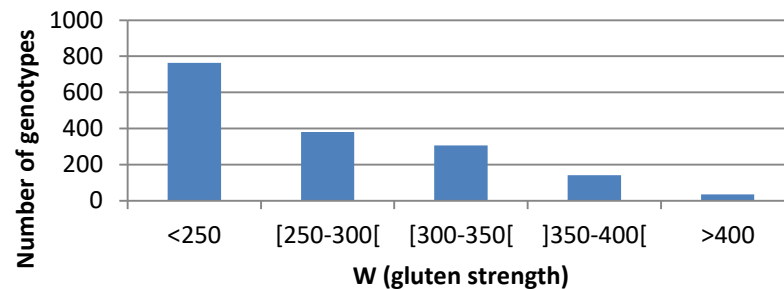
● Above average in SIDS, WM and Marchouch

Variability of elite wheat genotypes for protein content, gluten strength (W), and HMM Glutenin alleles at Merchouch, 2015

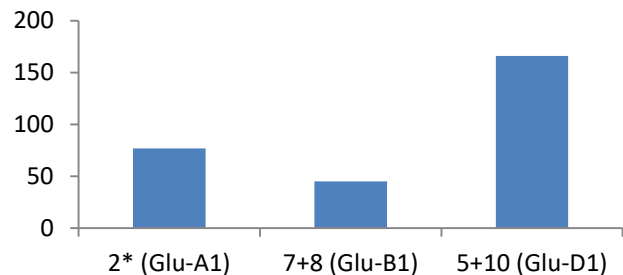
Protein (%)



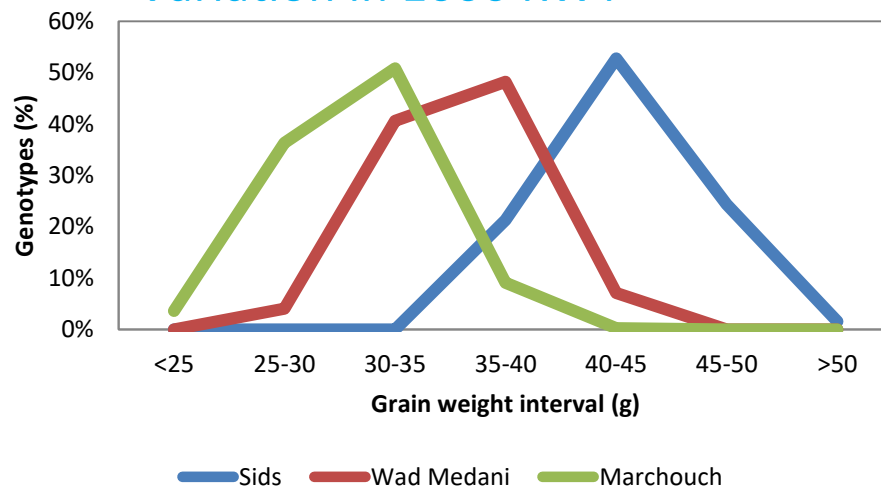
Gluten strength (W)



Frequency of HMW Glutenin Alleles



Variation in 1000 KWT

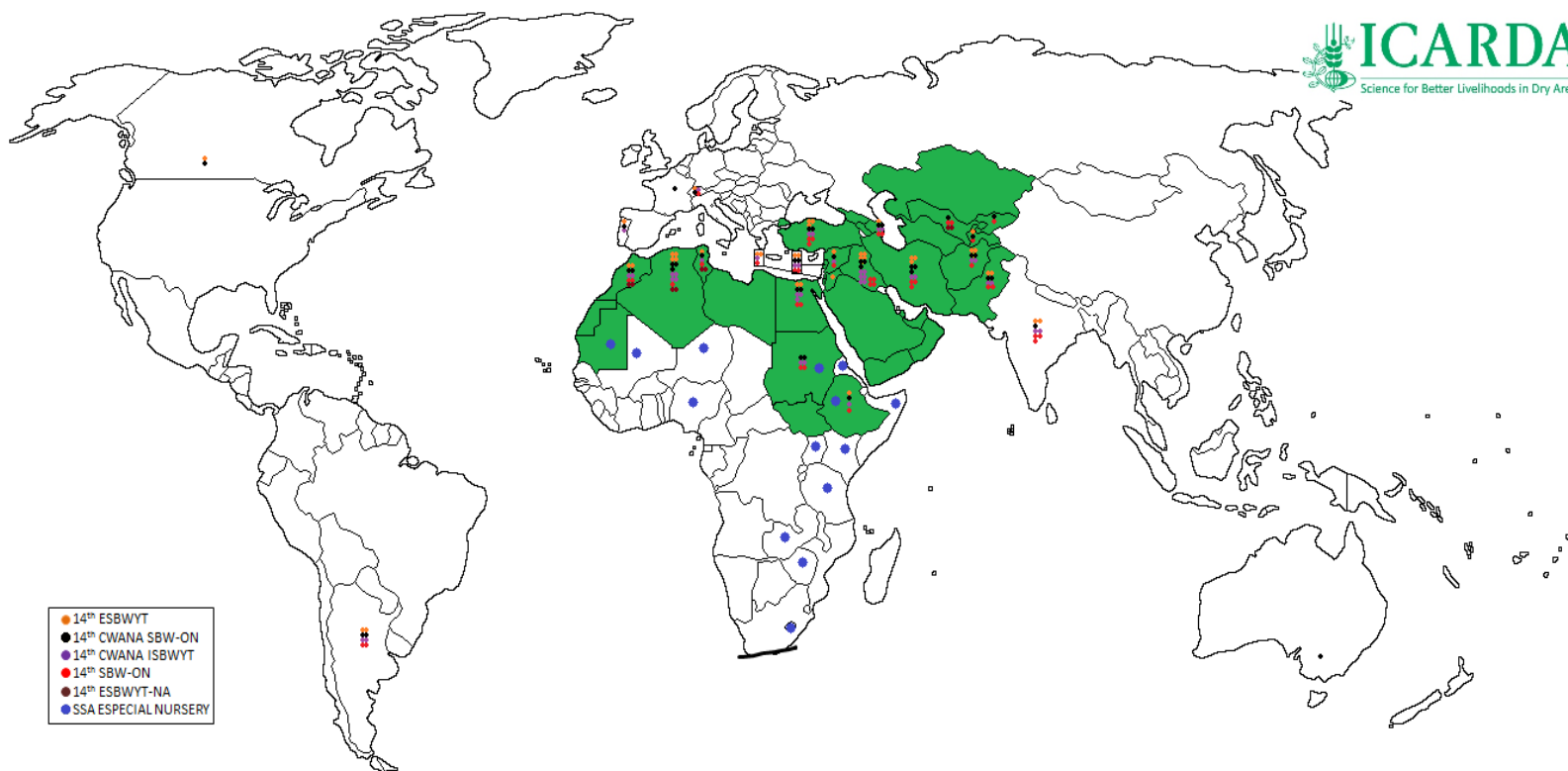


Distribution of International Nurseries and Yield Trials

The following International nurseries and yield trials have been distributed from Terbol station, Lebanon to more than 30 countries in the CWANA and SSA regions and beyond up on request from the NARS .

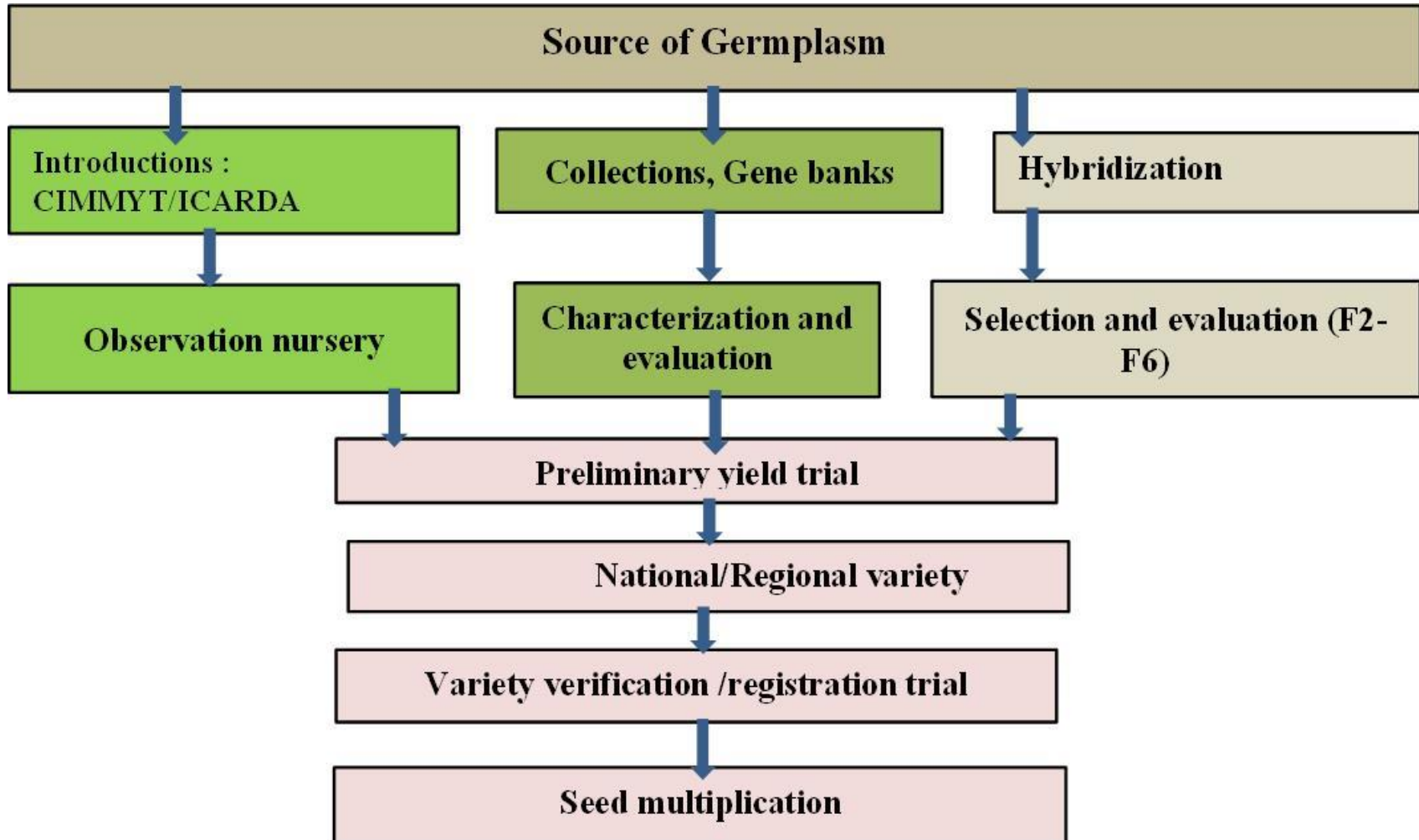
1. Spring bread wheat observation nursery for CWANA (CWANA SBWON)
2. Spring bread wheat observation nursery for heat tolerance (HT-SBWON)
3. Spring bread wheat yield trial for HT(ESBWYT-HT)
4. Spring bread wheat yield trial for dry-land environments (CWANA DSBWYT)
5. Elite spring bread wheat yield trial (ESBWYT)
6. Especial nursery for 12 countries in Sub Saharan Africa (AfDB project)

[www.icarda.org/research-sub/international nurseries](http://www.icarda.org/research-sub/international_nurseries)



Geographic distribution of ICARDA' s spring bread wheat international nurseries

Wheat breeding scheme at NARS level



Variety Release by the NARS

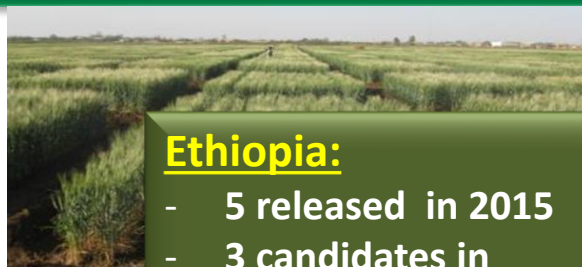
Variety Name	Type	Cross/Pedigree	Year of Release	Country
SIDS-13	SBW	KAUZ//TSI/SNB	2010	Egypt
HOGGANA	SBW	PYN/BAU//MILAN (= ETBW 5780	2011	Ethiopia
SHORIMA	SBW	UTQE96/3/PYN/BAU//MILAN	2011	Ethiopia
Shisham Bagh 013	SBW	CHAM-6/WW 1402	2013	Afghanistan
KARIM	SBW	T.AEST/SPRW//CA8055/3/BACANORA86	2011	Iran
GOUMRIA-3	SBW	VEE#7/KAUZ	2013	Sudan
GIZIL BUGDA	FWW	SAULESKU41/SADOVO1	2009	Azerbaijan
CHUMON	FWW	CADET/6/YUMAI13/5/NAI60/3/14.53/ODIN//CI13441/CANON	2012	Tajikistan
TACICAR	FWW	OR F1.158/FDL//BLO/3/SHI4414/CROW	2012	Tajikistan
BUNIYODKOR	FWW	DORADE-5//KS82117/MLT	2012	Uzbekistan
RIJAW	FWW	PATO/CAL/3/7C//BB/CNO/5/CAL//CNO/SN64/4/CNO//BAD/CHR/3/KL../6/SABALAN	2011	Iran
HUMA	FWW	PYN/PARUS/3/VPM/MOS83-11-4-8//PEW/4/BLUGIL	2011	Uzbekistan
Gizil Bugda	FW	SAULESKU41/SADOVO1	2014	Azerbaijan
OBORA	SBW	UTIQUE96/FLAG-1	2015	Ethiopia
DAMBAL	SBW	AGUILAL/3/PYN/BAU//MILAN	2015	Ethiopia

SARD SC project: Spring bread wheat candidate varieties for release



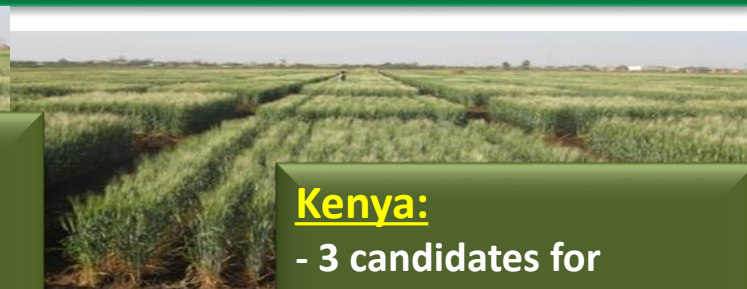
Nigeria:

- 4 released in 2015
- 3 candidates in 2016/17



Ethiopia:

- 5 released in 2015
- 3 candidates in 2016/17



Kenya:

- 3 candidates for 2016/17



Sudan

- 6 candidates in 2016/17

Mauritania:

- 2 recommended in 2015
- 1 candidate for 2016/17



Tanzania

- 2 candidates for 2015/16



Niger:

- 2 recommended in 2015
- 2 candidates for 2016/17



Mali

- 2 recommended in 2015
- 2 candidates for 2016/17



Zimbabwe:

- 1 released,
- 2 candidates for 2016/17



Senegal:

- 2 candidates for 2016/17

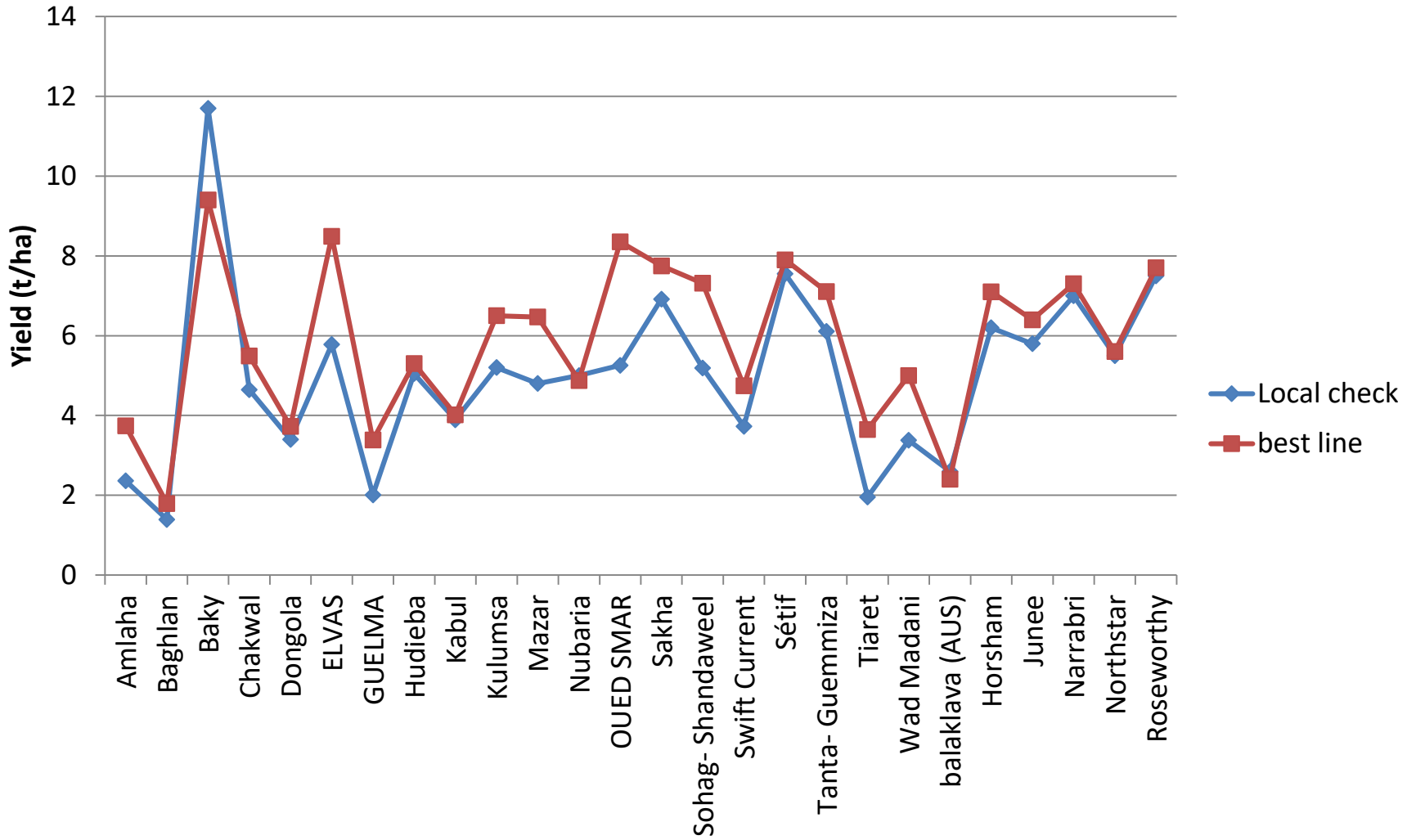
Nigeria:

- 4 released in 2015
- 3 candidates in 2016/17

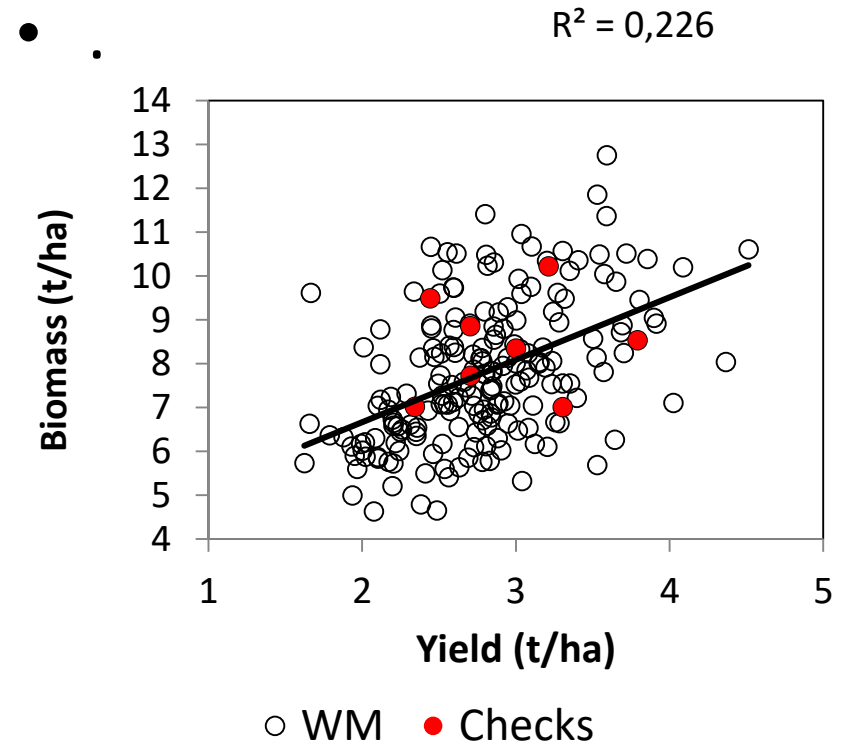
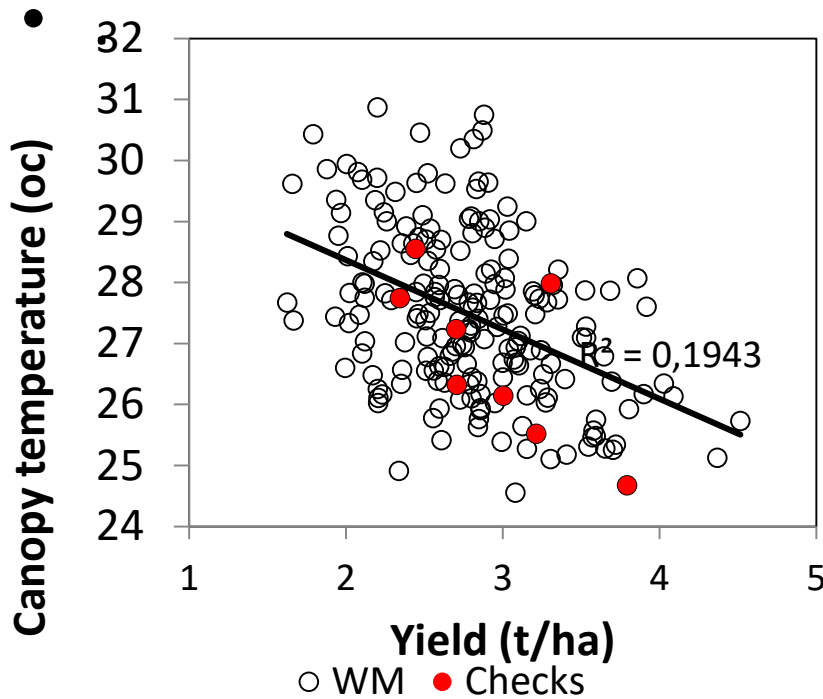
Zambia

- 2 candidates for 2016/17

Grain yield performance of the best ICARDA line and the local check across locations in the 16th ESBWYT, 2016



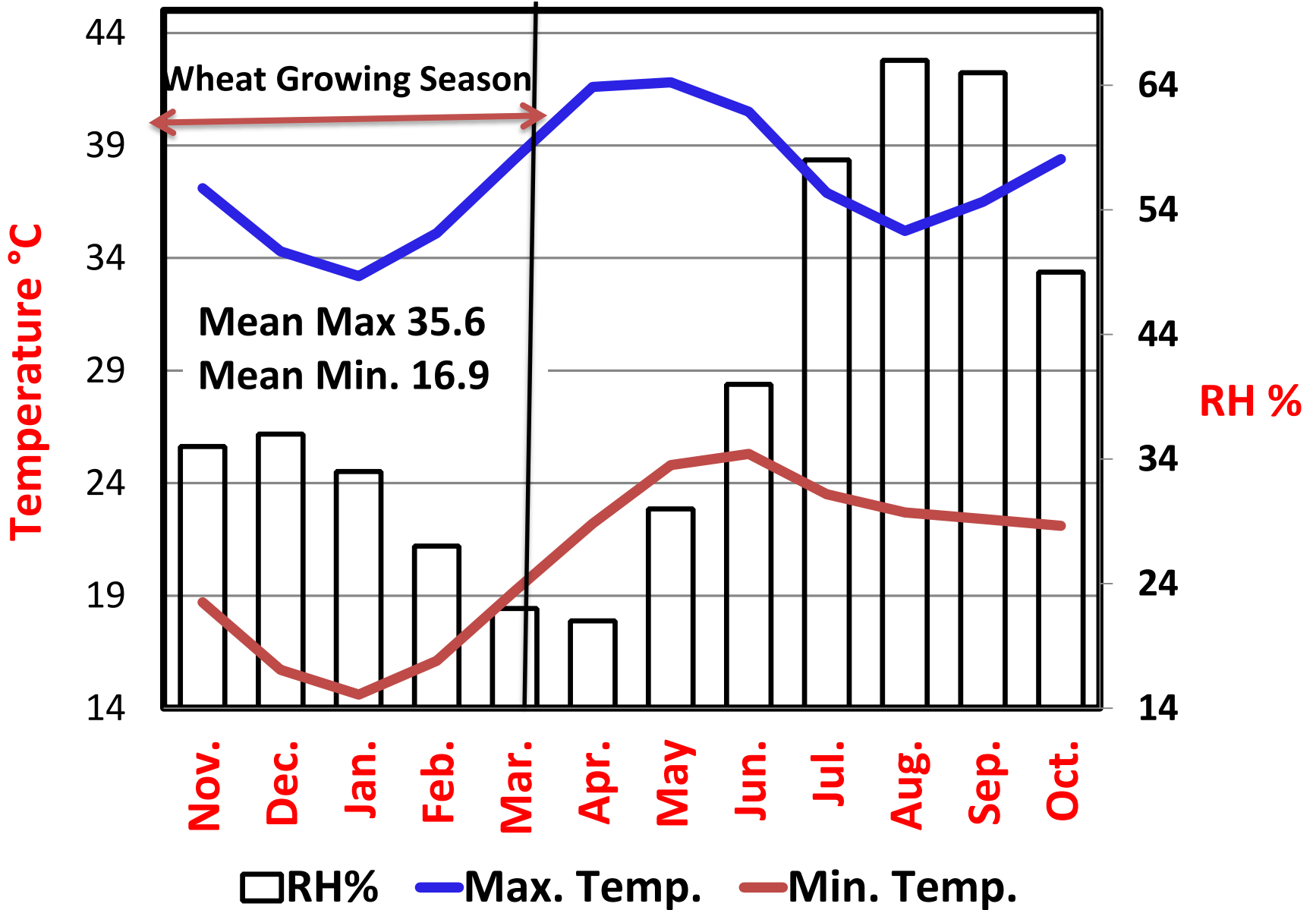
Association among key traits



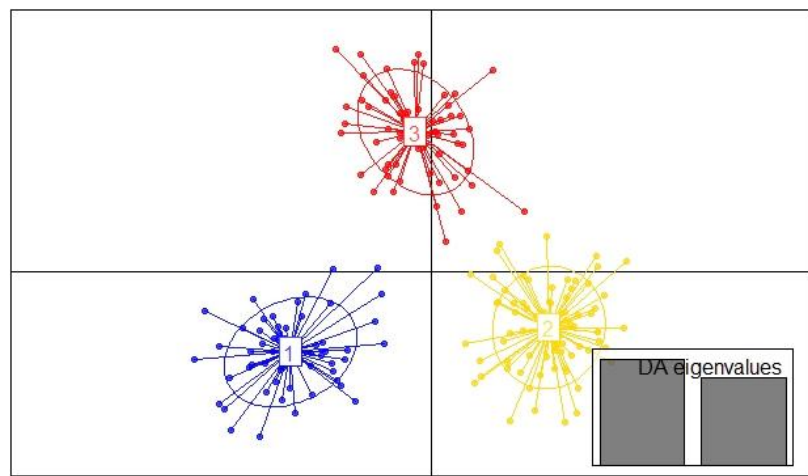
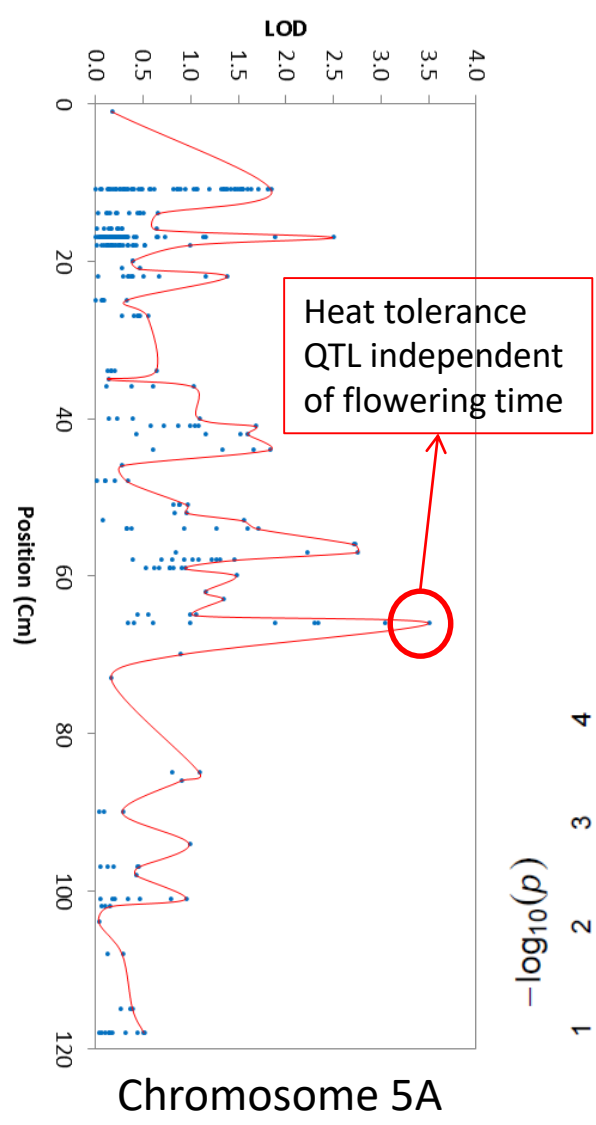
Pedigree analysis : synthetic hexaploid wheats (SHWs) ; *T. dicoccoides* in their background.

Long Term Average of Min. Max. Temperatures and RH

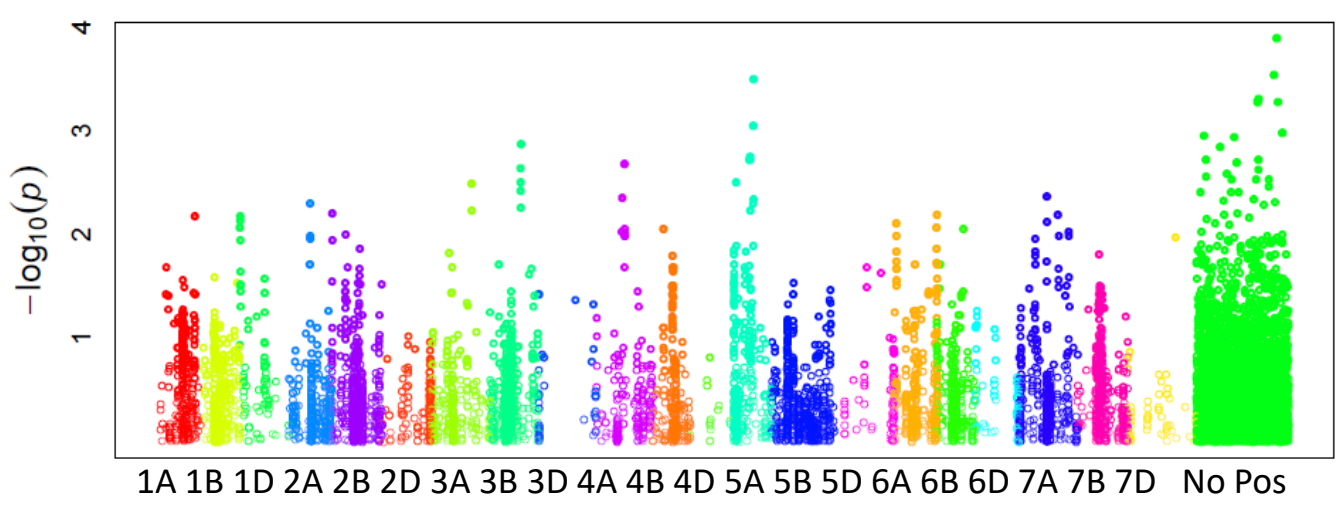
Wad Medani Sudan



Identification of novel QTL associated to Heat tolerance in Spring Bread Wheat ICARDA elite lines



Population structure



Genetic variability of elite spring bread wheat genotypes for hybrid wheat potential

Trait	Openness of floret (°)	Duration of floral opening (min)	pollen mass (mg)	pollen viability	Anther length (mm)	% anther extrusion	pollen shedding	Stigma length
Min	48	88	55	2.2	12	8.04	0.32	24
Max	87	135	140	14.67	28.6	15.92	8.8	107
Mean	67.5	111.5	97.5	8.43	20.3	11.98	4.56	65.5



Openness of the florets



Extruded anthers



Pollen viability test

Capacity building: short and long term trainings

Short term training : Classical and Molecular Approaches in Wheat Breeding



MSc & PhD Students

Name	Sex	Country	Degree level	Study area
Sahar Bennani	F	Morocco	PhD	Drought tolerance
Samira El-Hanafi	F	Morocco	PhD	Hybrid wheat
Sawsan Tawkaz	F	Syria	PhD	Doubled haploid techniques
Yewbdar	F	Ethiopia	M.Sc.	Yellow rust
Choghag	F	Lebanon	M.Sc.	Drought tolerance
Sofian	M	Sudan	PhD	Heat stress
Tilahun Mekonnen	M	Ethiopia	PhD	Septoria
Kenza	F	Morocco	PhD	Quality
Tamirat	M	Ethiopia	M.Sc	Triple rust
El-Fadil	M	Sudan	PhD	Heat stress
Mathewos	M	Ethiopia	PhD	Stem rust

For more details, refer our recent publications

- W. Tadesse**, F. C. Ogbonnaya, A. Jighly, M. Sanchez-Garcia, Q. Sohail, S. Rajaram, and M. Baum (2015) Genome-wide Association Mapping of Yield and Grain Quality Traits in Elite Winter Wheat Genotypes. PLOS ONE | DOI:10.1371/journal.pone.0141339
- W. Tadesse**, F.C. Ogbonnaya, A. Jighly, K. Nazari, S. Rajaram, and M. Baum. 2015. Association Mapping of Resistance to Yellow Rust in Winter Wheat Cultivars and Elite Genotypes Crop Sci. doi: 10.2135/cropsci2013.05.0289
- Mui-Keng , Mustapha El-Bouhssini, Livinus Emebiri, Ossie Wildman, **Tadesse W**, Francis C. Ogbonnaya (2015) A SNP marker for the selection of *HfrDrd*, a Hessian fly-response gene in wheat. Molecular Breeding. DOI:[10.1007/s11032-015-0410-6](https://doi.org/10.1007/s11032-015-0410-6)
- Jighly A, Oyiga BC, Makdis F, Nazari K, Youssef O, **Tadesse W**, Abdalla O, Ogbonnaya FC (2015) Genome-wide DArT and SNP scan for QTL associated with resistance to stripe rust (*Puccinia striiformis* f. sp. tritici) in elite ICARDA wheat (*Triticum aestivum* L.) germplasm. Theor Appl Genet DOI 10.1007/s00122-015-2504-2
- W. Tadesse**, **M. Nachit**, **O. Abdalla** and **S. Rajaram** (2015). **Wheat Breeding at ICARDA: Achievements and Prospects in the CWANA Region** . In **Alain Bonjean, Bill Angus and Maarten van Ginkel (eds) World Wheat Book Volume 3**.
- W. Tadesse**, S. Rajaram, F. C. Ogbonnaya, M. Sanchez-Garcia, Q. Sohail, and M. Baum (2015) **Wheat Breeding: Challenges and Prospects in the 21st Century**. Springer
- W. Tadesse**, S. Hafez, M. Sanchez-Garcia, R. Sharma, I. Tahir, S. Bennani, Z. Bishaw, A. Abdallat, M. El-Bouhssini, K. Nazari, A. Amri, S. Assefa, and M. Baum. 2015. Improving wheat yield in water limited environments across the CWANA region. 9th IWC, Sydney.
- M. Solh, HJ Braun and W. Tadesse** . **Wheat: Save and Grow book Chapter, FAO, Rome**
- W. Tadesse**, A. Amri, M. Sanchez-Garcia, M. El-Bouhssini, T. Oweis, M. Karrou, P. Somanagouda, F. Bassi, and M. Baum. 2015. Improving wheat cultivation in North Africa

Summary

- Combining major genes with minor genes
- ❖ availability of molecular tools: functional markers
- key phenotyping plat forms
- ICARDA's gene bank holds unique FIGS sets
- Closer collaboration and partnership with NARSs
- High expectations vs climate change and population increase

Dr Borlaug in 1970: “Yield increase vs population monster”

Acknowledgements

- ICARDA's Wheat Team+ M.Sc. and PhD students
- NARSs in the CWANA + SSA
- INRA-Morocco; ARC-EGYPT; AUB & AREC-Lebanon; EIAR-Ethiopia; ARC-Sudan and Turkey
- WHEAT CRP, GRDC, AfDB, Arab fund, Kuwait fund

Thank you

