Genotypic structures in CIMMYT international yield trials targeted to irrigated and semi-arid environments

Susanne Dreisigacker

GWP, CIMMYT

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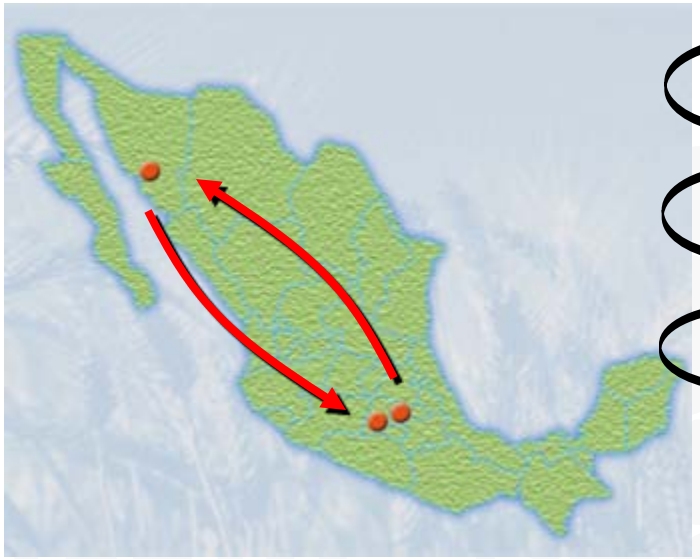
CIMMYT Global Wheat Program

Centralized breeding approach

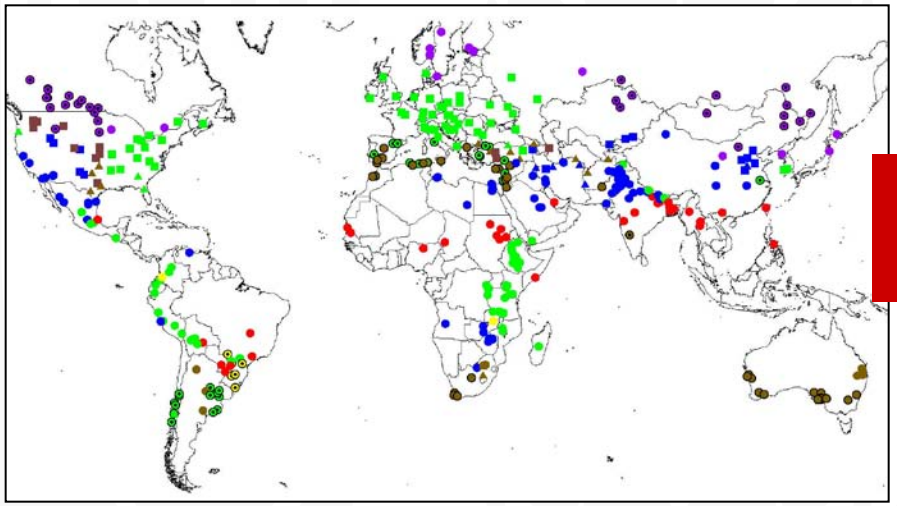


Crossing

Selection: Shuttle Breeding

Evaluation of fixed lines in Mexico

Distribution of improved germplasm through the International Wheat Improvement Network (IWIN)



Collection and interpretation of multi-location data

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IWIN

The role of formalized international screening nurseries and yield trails is to provide…..

- **parental materials for accelerating the breeding programs**
- **means of evaluating promising breeding materials on a worldwide basis,**
- **basic information about adaptability of varieties, yield potential, disease, and pest resistance,**
- **indications if varieties might serve as immediate introduction into potentially high production wheat areas,**
- **partnerships in an international collaborative system**

Rajaram *et al.*, 2002

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Evolution of the IWIN 1950s-2000s

Decade	Main focus	Main nurseries added
1950 (USDA)	Rusts	Int. Stem Rust Trial for North and South America
1960s Early CIMMYT	Provide germplasm with broad adaptation, high yield potential, multiple disease resistance and test these qualities over time and space	First; Int. Durum Yield Trail; Int. Bread Wheat Screening Nursery; Int. Triticale Yield Trail; Int. Triticale Screening Nursery
1970s	Provide high yielding, broadly adapted, day length insensitive, multiple disease resistant germplasm. Start of spring by winter wheat breeding program, special nurseries for disease resistance	CBs; F2's irrigated and dryland; Int. Septoria Screening Nursery; Elite Spring Wheat Yield Trial; Regional Disease Trap Nursery
1980s	As before but with additional adaptation for diverse environments, designated as mega-environments. Program for wheat for non-traditional warmer climates	Semi-Arid Wheat Screening Nursery; Acid Soils Wheat Screening Nursery; High Rainfall Wheat Screening Nursery; International Disease Trap Nursery, KB Screening Nursery
1990s	As before but with additional stratification of environments including higher latitudes with day length sensitive wheat for eastern Europe and central Asia	High Rainfall Wheat Yield Trial; High Temp. Wheat Yield Trial; Semi-Arid Wheat Yield Trail; Warmer Area Wheat Screening Nursery; High Latitude Wheat Screening Nursery
2000s	Additional specialty nurseries for diseases and other traits	Scab Resistance Screening Nursery; South Asia Micronutrient Yield Trial, Int. Adaptation Trial, Global Adaptation Wheat Yield Trail, Stem Rust Screening Nursery

Byerlee & Durbin, 2010

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Byerlee & Durbin, 2010

Two examples of international yield trials

ESWYT: Elite spring wheat yield trial

Distributed each year since 1979

Targeted to highly productive irrigated wheat producing areas (ME1)

Main breeding objectives: high yield potential, rust, lodging

SAWYT: Semi-arid wheat yield trial

Distributed each year since 1991

Targeted to semi arid wheat areas worldwide (ME4)

Main breeding objective: drought tolerance

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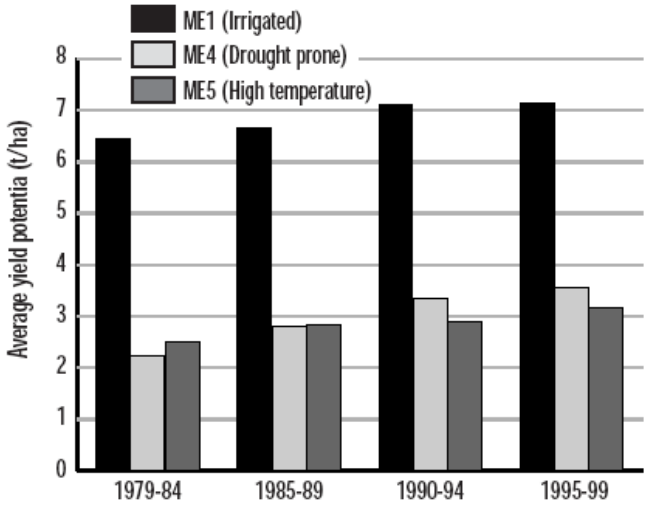
Determining the relationship among test locations and yield gain over time

CIMMYT's primary yield test location associated well with global locations in irrigated environments

Lack of associations with semi-arid environments outside of South Asia

Advance in yield gain in irrigated and drought prone environments observed in different periods of time



Trethowan and Crossa, 2007

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Genotypic characterization

ESWYT

- 23 ESWYT from 1979/1980 to 2004/2005
- 658 lines
- Genotypic data in 2007: 1447 DArT (A: 487, B:798, D:124)

SAWYT

- 17 SAWYT from 1991/1992 to 2007/2008
- 760 lines
- Genotypic data in 2010: 2150 DArT (A:462, B:668, D:275, unknown: 749)

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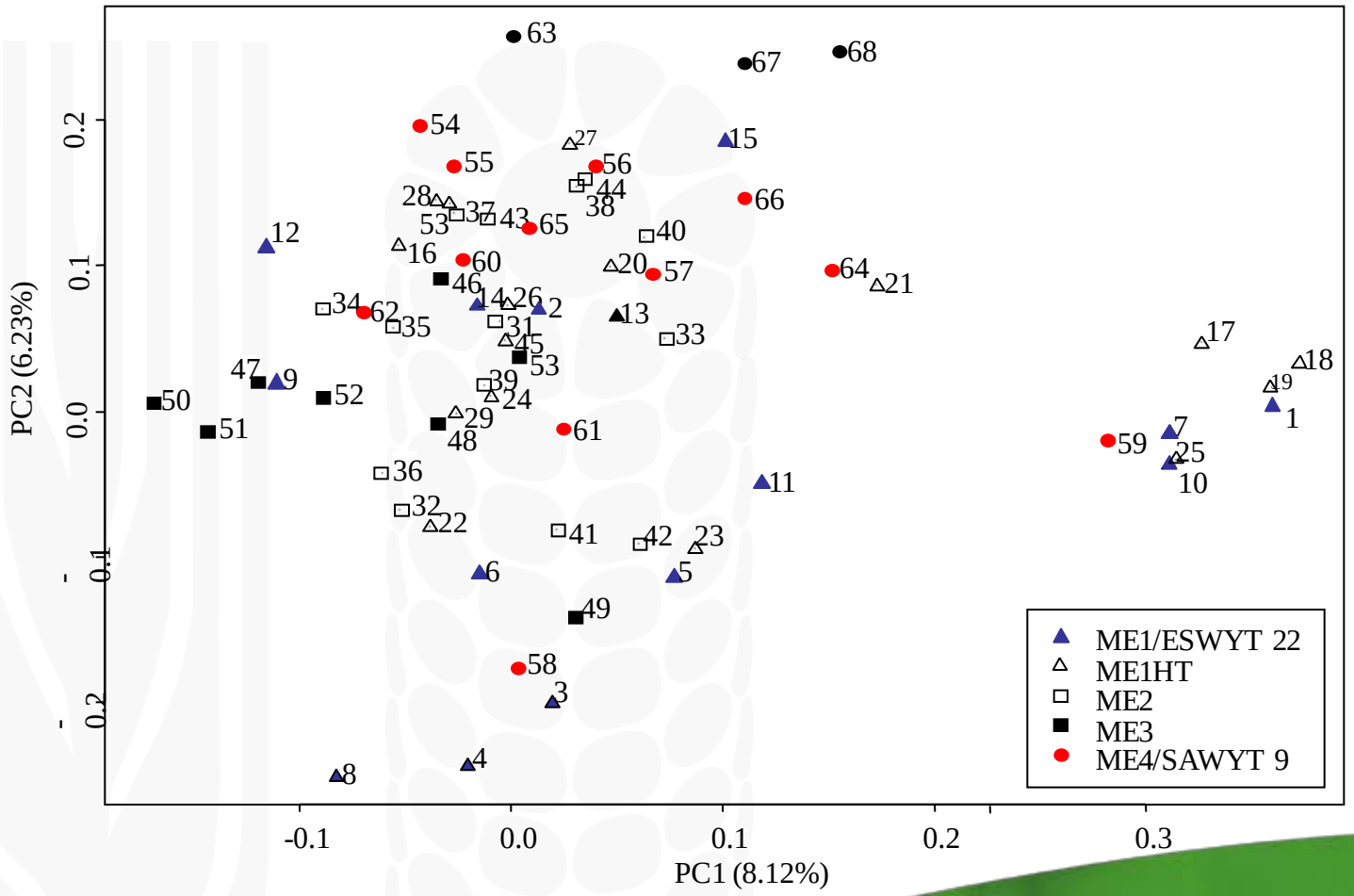
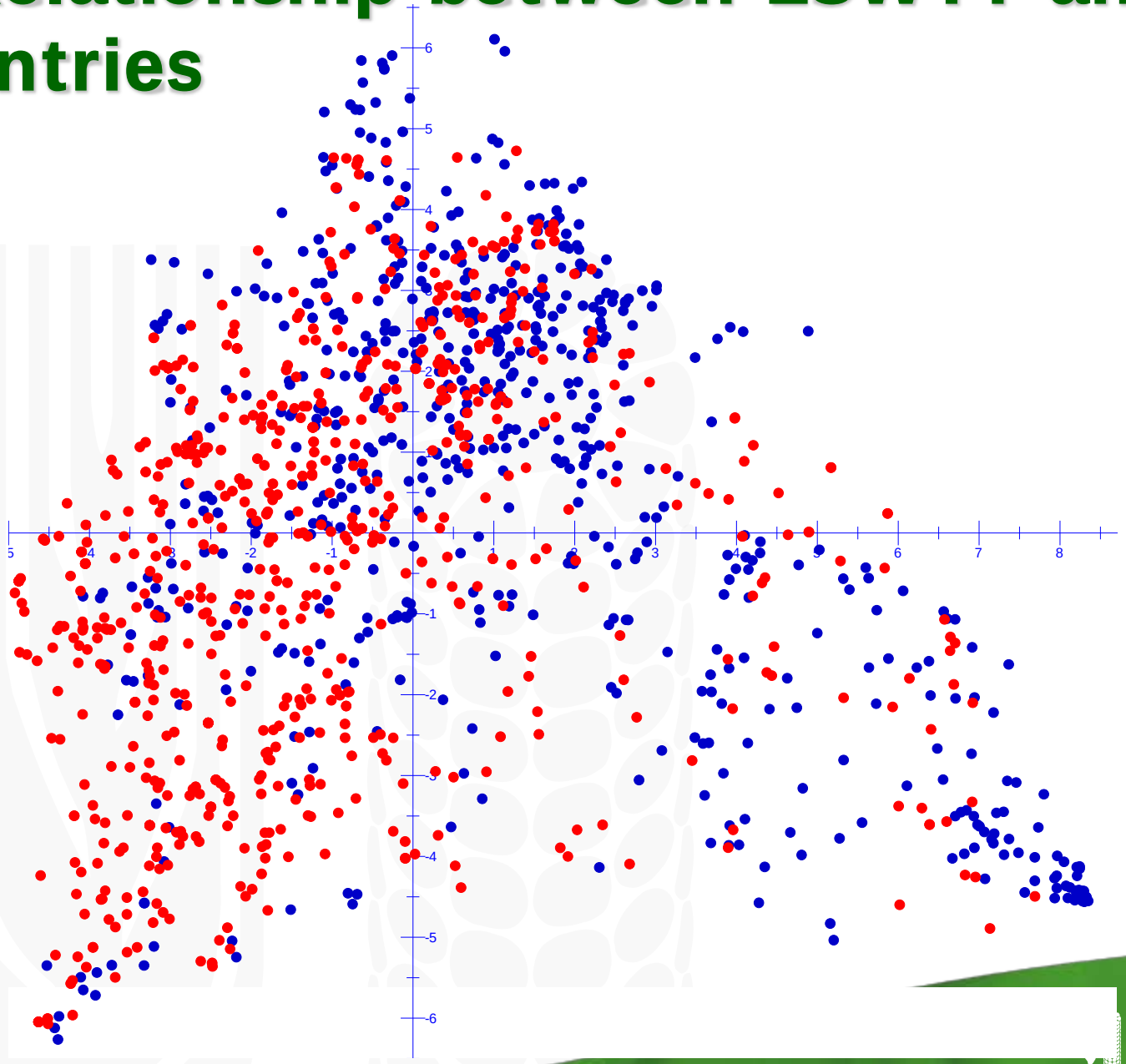
First attempt:

Genotypic characterization of CIMMYT advanced lines targeted to five Mega-environments (ME)



Dreisigacker *et al.*, 2004

Relationship between ESWYT and SAWYT entries



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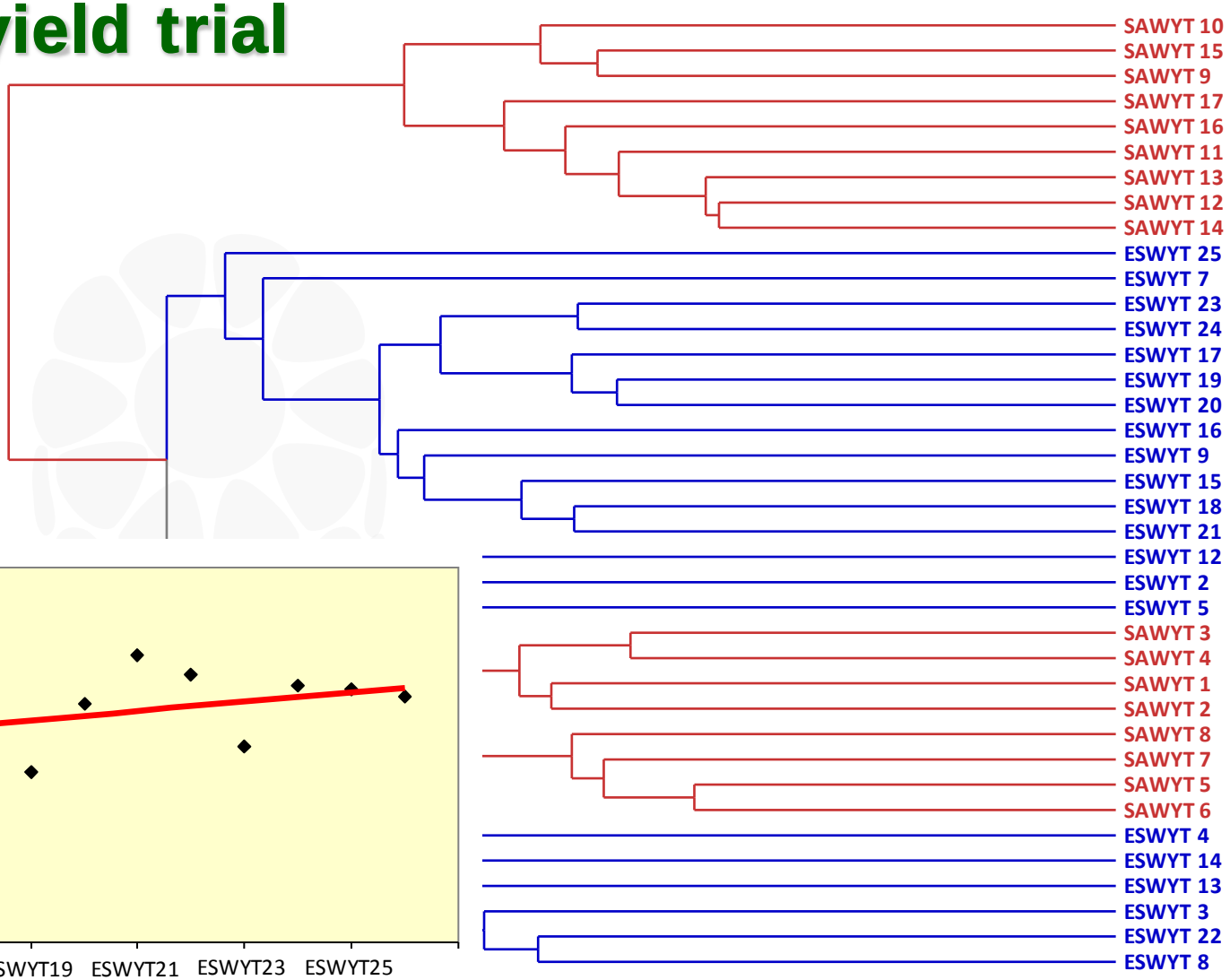
Relationship between ESWYT and SAWYT entries grouped by yield trial



Spillover of wheat lines from favorable to marginal environments

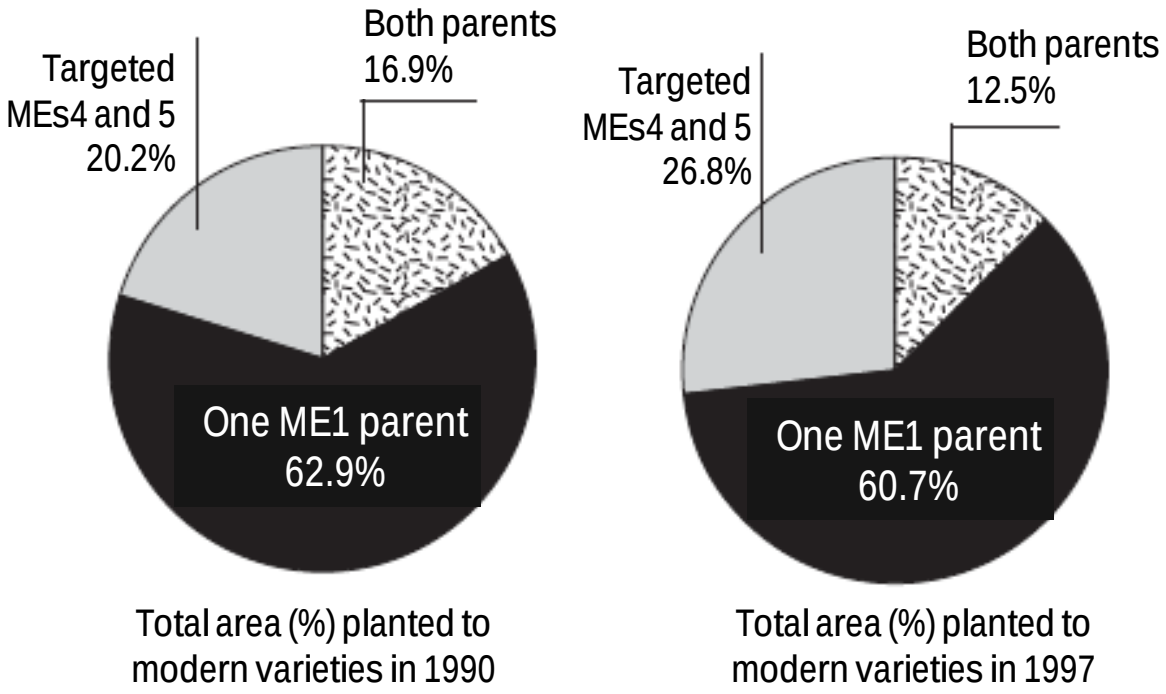


Figure 3. Effect of ME1 (irrigated) and ME2 (high rainfall) spillovers on yield potential in ME4 (drought prone) and ME5 (high temperature), 1997.

Lantican *et al.,* 2001

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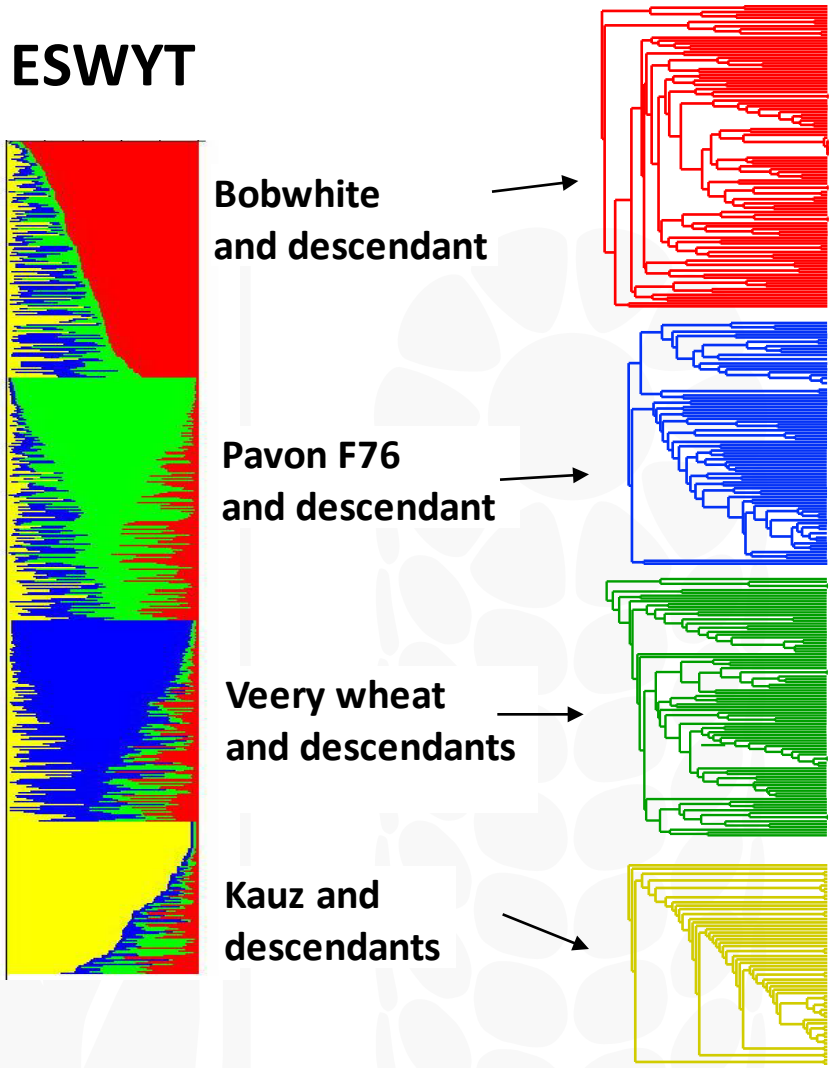
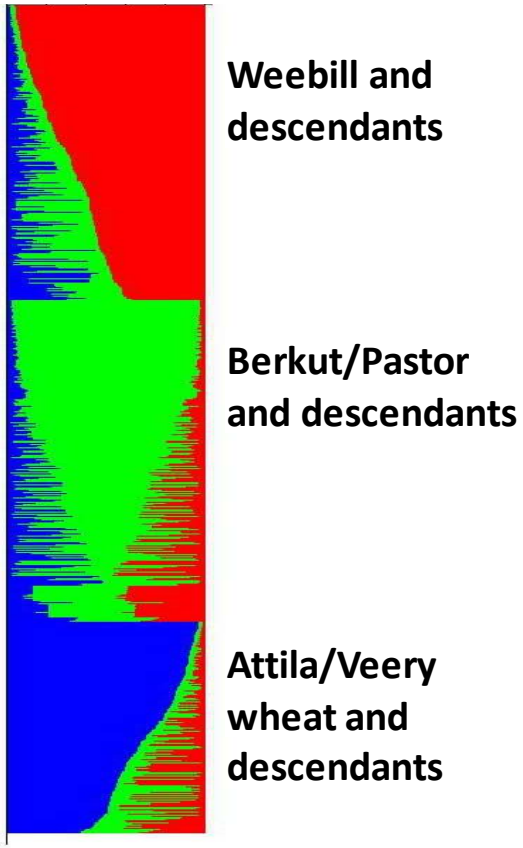
Population structure within each yield trial





V. Arif *et al.*,

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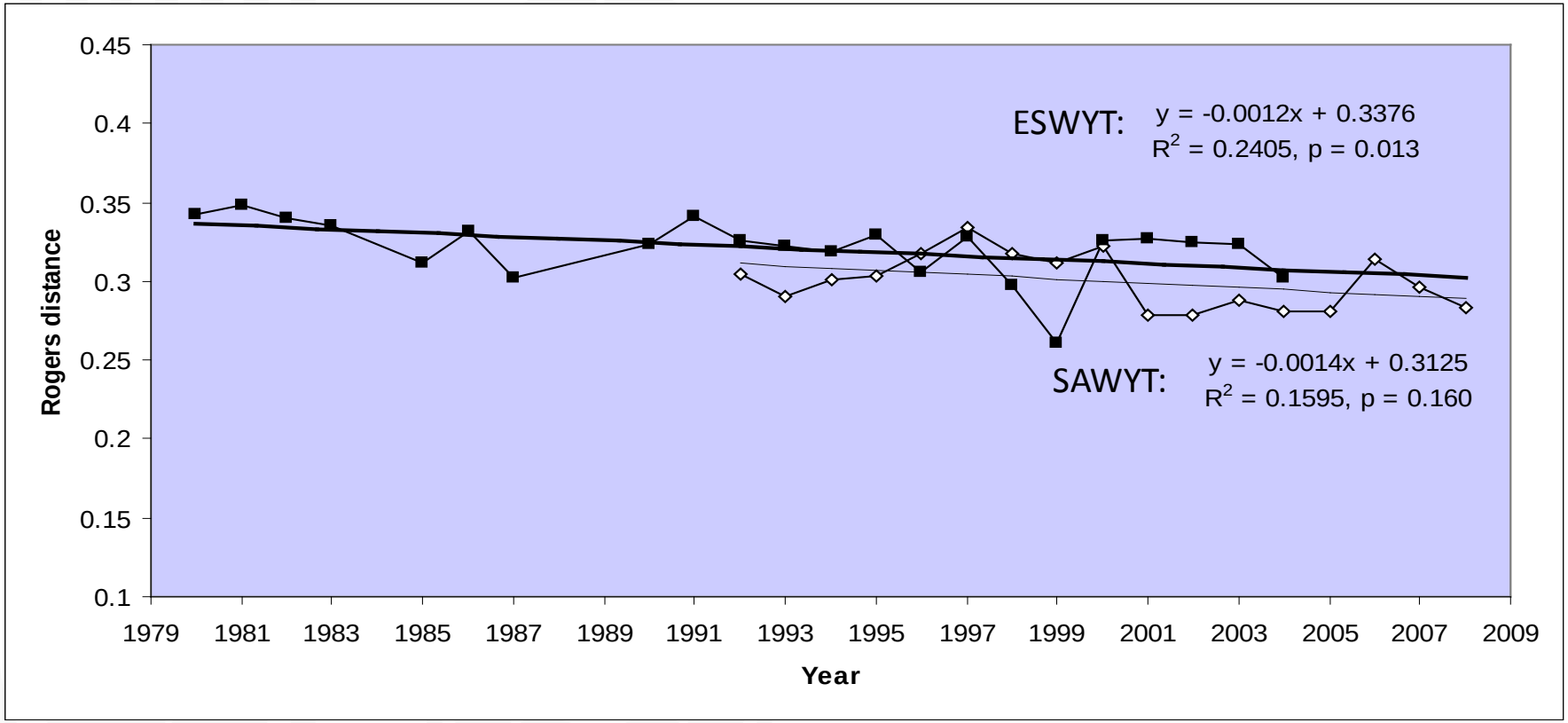
Genetic diversity over time

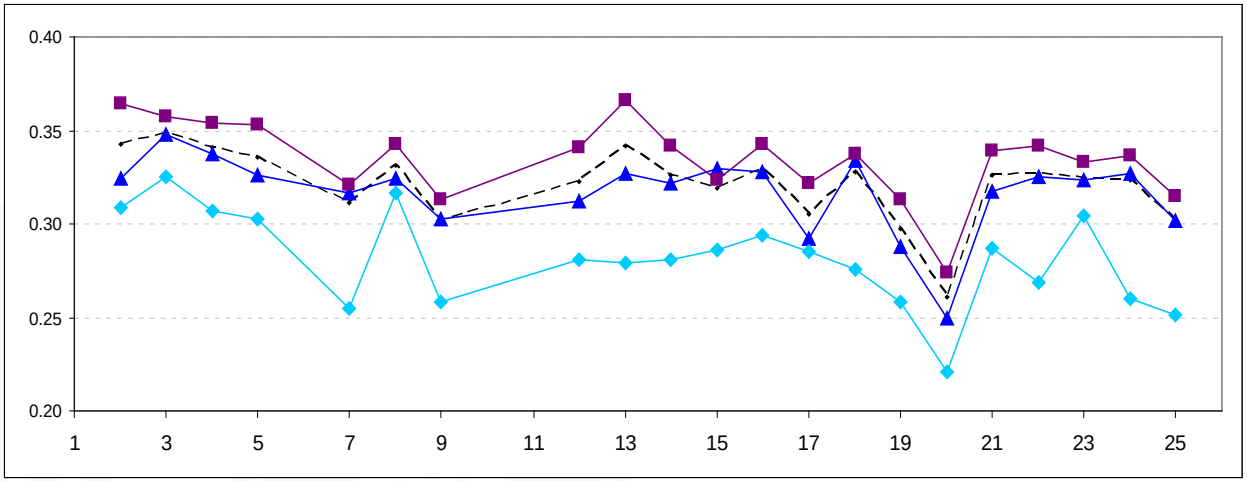
Genetic diversity in modern agriculture is a function of the range of varieties are grown at any time

Only a small number of available varieties are disseminated

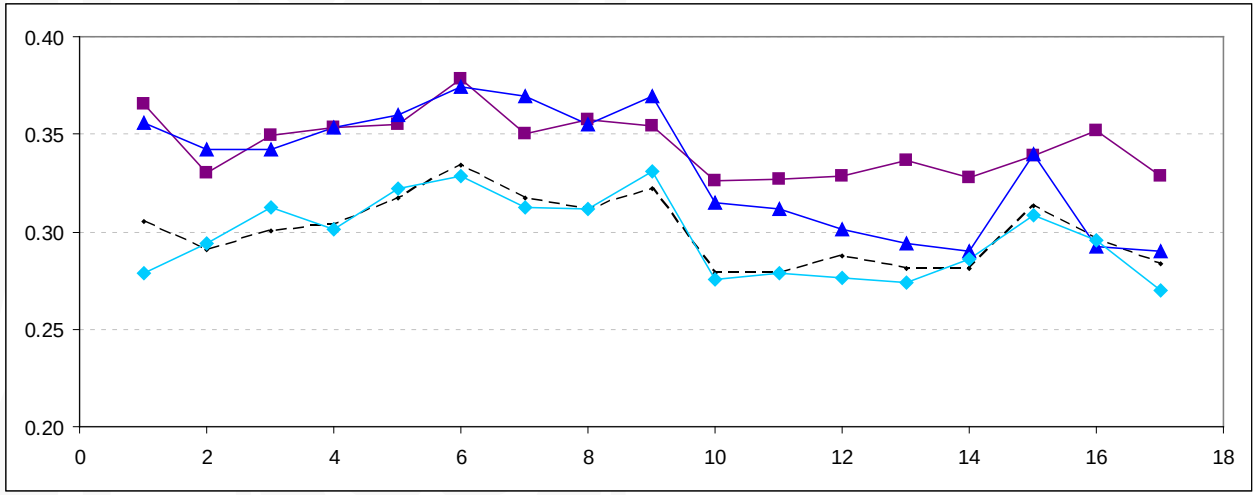


Trends of genetic diversity over time

ESWYT



SAWYT



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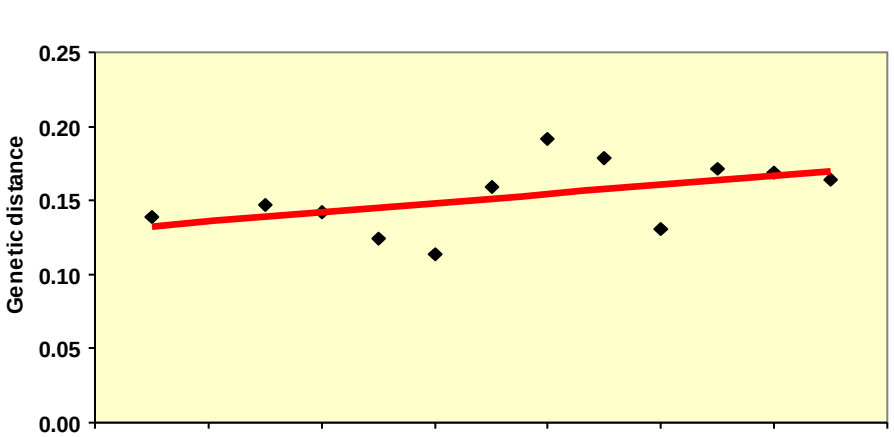
Genetic diversity among ESWYT and SAWYT



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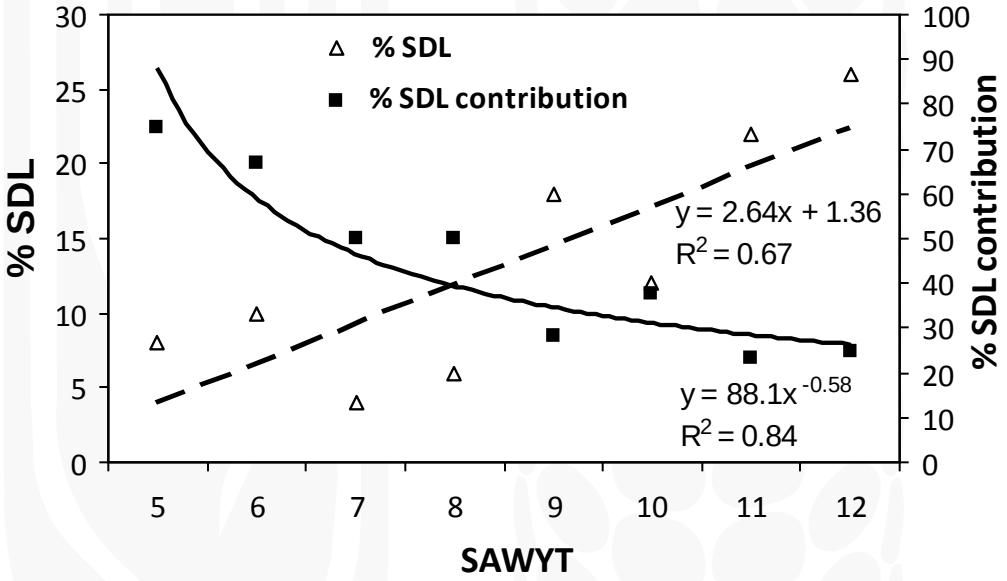
Introduction of synthetic derived lines (SDL) in the SAWYT

Statistic	A+B				D			All SSRs		
	DW†	SHW	BW	SDL	SHW	BW	SDL	SHW	BW	SDL
N_a	2.27	2.67	2.17	3.82	4.61	2.25	4.50	3.27	2.21	4.07
H_S	0.40	0.40	0.37	0.46	0.70	0.37	0.50	0.50	0.37	0.47
P	0.75	0.85	0.67	0.97	0.90	0.68	0.97	0.90	0.67	0.97

† DW: durum wheat; SHW: synthetic hexaploid wheat; BW: bread wheats; SDL: synthetic derived lines.



Continuous selection for the most favorable loci in synthetic derivatives lines

Lage et al., 2007, Zhang *et al.,* 2005

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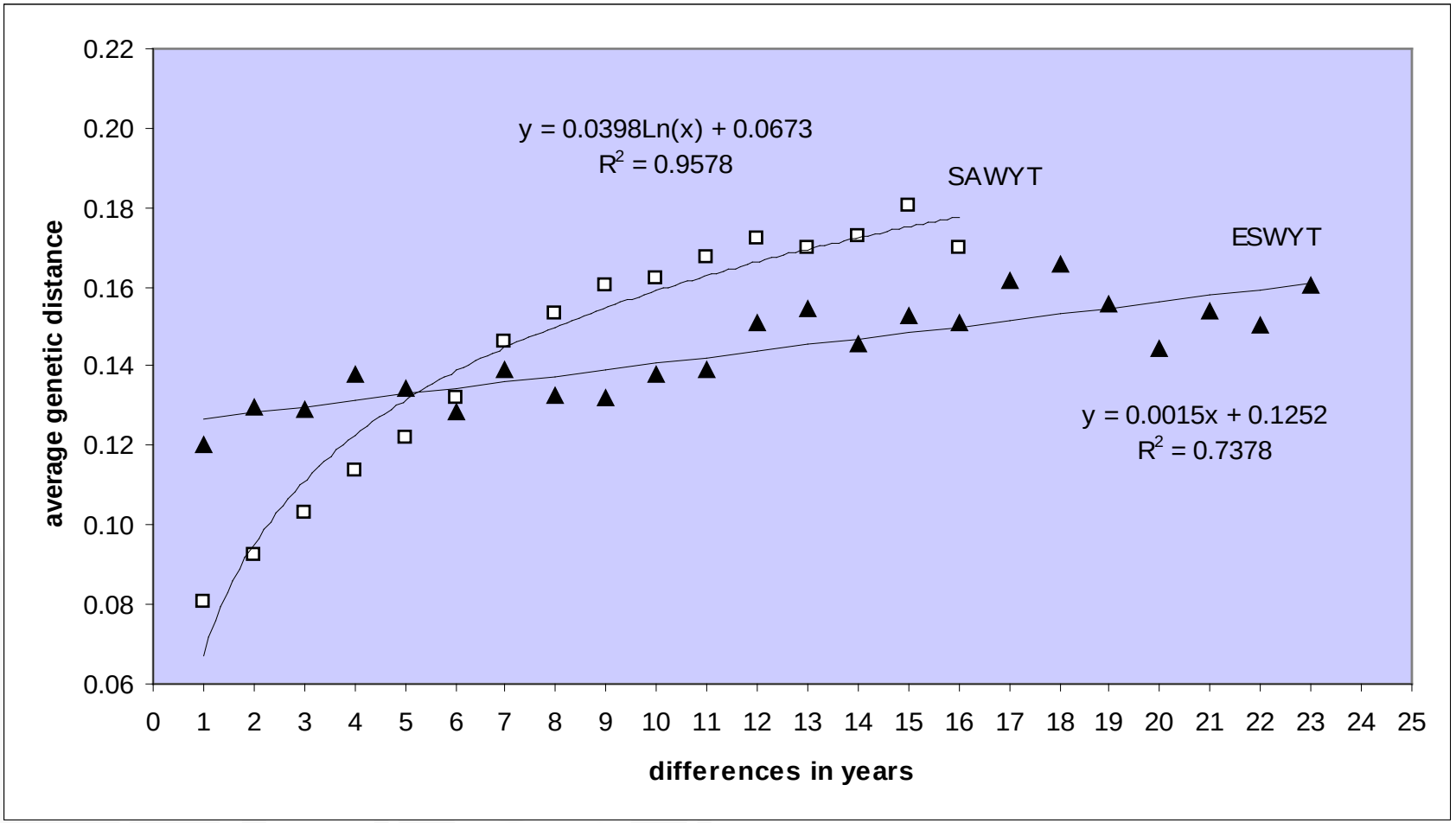
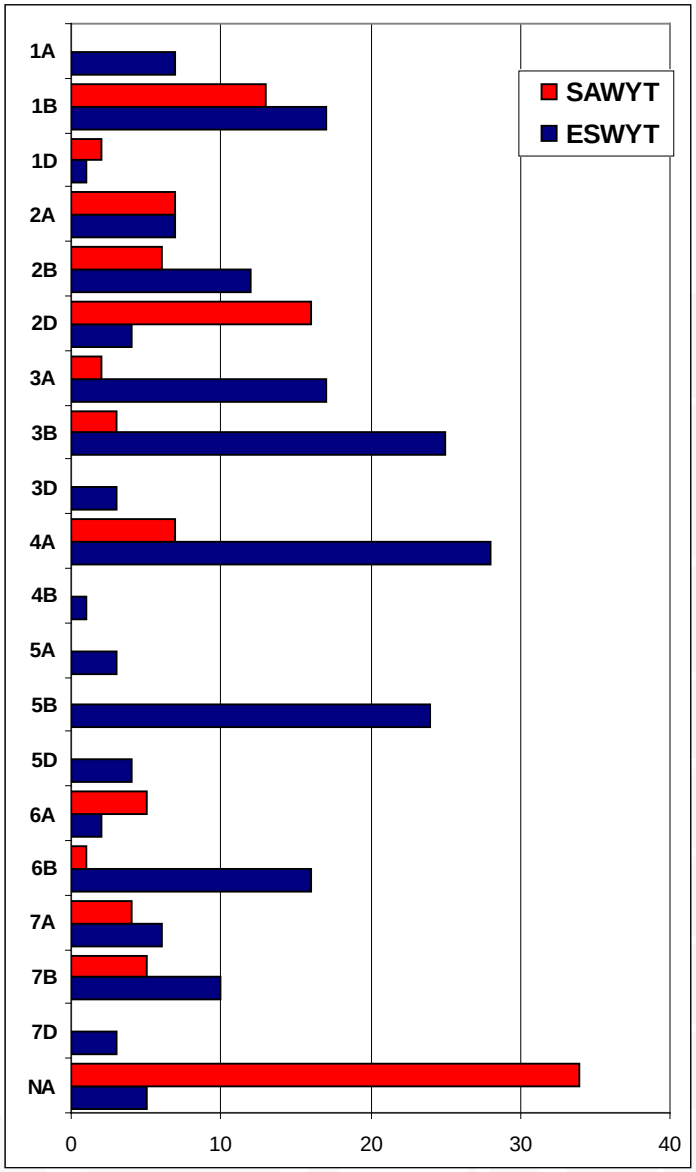
Average genetic distance between trials grouped according their differences in years

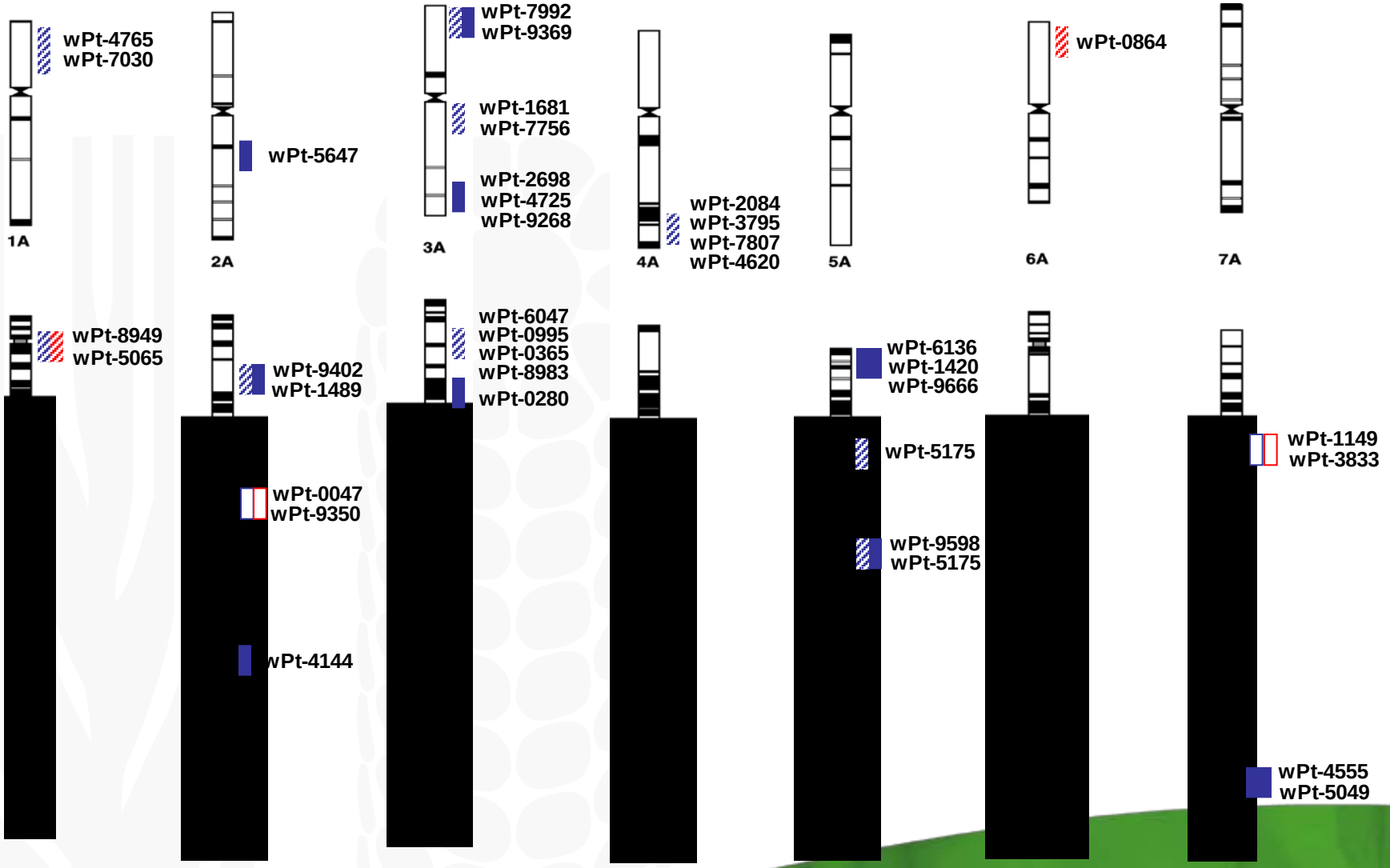




Markers with significant change of allele frequency

	ESWYT	SAWYT
Total:	195	108
A:	70	25
B:	105	28
D:	15	20
unknown	5	35

Markers-trait associations



Crossa *et al.*, 2007,Crossa *et al.*, 2010

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Conclusions

- Selection for environment adaptation has led to the establishment of two different gene pools in the CIMMYT germplasm
- Heterotic groups within each gene pool were identified and shaped by prominent CIMMYT parents
- Genetic diversity the both international yield trails has been stable over time
- The B genome revealed the highest genetic variation and allele frequency changes in the ESWYT and SAWYT germplasm
- Genomic regions associated to yield and rust could be confirmed in ESWYT and are most likely different in the SAWYT

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Thank you for your attention

CIMMYT team:

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