DEVELOPING ALFALFA VARIETIES FOR A WATER-CHALLENGED FUTURE

Ian Ray
Dept. of Plant and Environmental Science
New Mexico State University

OVERVIEW

EVALUATING ALFALFA POPULATIONS FROM AROUND THE WORLD FOR PRODUCTIVITY UNDER DEFICIT IRRIGATION

"DROUGHT TOLERANT" CULTIVAR DEVELOPMENT PROGRAM AT NMSU

WATER STRESSED ALFALFA PHYSIOLOGY & DEVELOPMENT STUDIES

IDENTIFYING DNA MARKERS ASSOCIATED WITH ALFALFA PRODUCTIVITY DURING DROUGHT

DEPLOYING "BIOMASS PRODUCTIVITY" DNA MARKERS INTO ALFALFA CULTIVARS

IDENTIFYING POPULATIONS THAT ARE PRODUCTIVE UNDER DEFICIT IRRIGATION

USDA ars United States Department Of Agriculture Agricultural Research Service

Germplasm Resources Information Network

ARS Home | About ARS | Help | Contact Us

Email this page

Search

Enter Keyw Go

Advanced Search

Browse By Subject

- Home
- Collections
- Search GRIN
- Request Germplasm
- pcGRIN
- Crop Germplasm Committees
- Repository Home Pages
- FAQ
- Links

National Plant Germplasm System

Accession Area Queries

Crop Science Registration

Plant Variety Protection

Taxonomic Queries

Research Crops and Descriptor/Evaluation Data Queries

Search Multiple Databases

Download Data in FAO MCPD format

USDA ALFALFA GROUP

Query Results:

Name: Alfalfa
Restricted to active and available accessions

List of accessions found

1.DLEG 890227 Medicago sativa subsp. sativa DLEG 890227
2.NSL 102063 Medicago sativa subsp. sativa V-1
3.NSL 102064 Medicago sativa subsp. sativa Y-1
4.NSL 102065 Medicago sativa subsp. sativa Z-1
5.NSL 102250 Medicago sativa subsp. sativa RINCON
6.NSL 102254 Medicago sativa subsp. sativa CHILEAN 21-5-5
7.NSL 102939 Medicago sativa subsp. sativa WL 220
8.NSL 103799 Medicago sativa subsp. falcata C-6

//////////////////

3470.W6 5894 Medicago sativa subsp. falcata 99
3471.W6 87 Medicago sativa subsp. sativa W6 87
3472.W6 9369 Medicago sativa subsp. sativa ABY-AF 1409.00
3473.W6 9370 Medicago sativa subsp. sativa ABY-AF 1410.00
3474.W6 9384 Medicago sativa subsp. glomerata W6 9384
3475.W6 9385 Medicago sativa subsp. sativa W6 9385

USDA ALFALFA WORKGROUP

ALFALFA Descriptors in GRIN

Click checkboxes to select descriptors for query, click the descriptor name for a definition. To download descriptor information use the long form and the download icon.

CHEMICAL

- CRUDELEAF
- CRUDESTEM
- PROTBYPASS

CYTOLOGIC

- CHROMNUM

DISEASE

- ANTHRAC
- APHAN
- BACTWILT
- DOWNYMILD
- FUSWILT
- LEAFSPOT
- LEPTOSPOT
- PHYROOTROT
- RHIZOC
- SCLEROT
- SPRBLSTEM
- STEMPHLFSP
- VERTWILT

GROWTH

- CRNSTEMDIA
- CROWNWIDTH
- FALLGROWTH
- GROWHABIT
- RECOVRATE
- ROOTDIAM2
- SDLGVIGOR
- TAPROOTDIA

INSECT

- BLUEAPHID
- LYGUSBUG
- PEAAPHID
- POTLEAFHOP
- ROOTCURC
- SNOUTBEETE
- SPOTALFAPH

MOLECULAR

- GENEDIST

MORPHOLOGY

- CROWNBRAN
- CROWNDEPTH
- CROWNORIG
- CRWNBUDNUM
- DETTAPPERC
- DETTAPPOS
- FIBRTMASS
- FLOWCOLOR
- LEAFSIZE
- ROOTNUM2
- ROOTPOS2
- SEEDWGT
- UILENGTH

OTHER

- IMAGE

PHENOLOGY

- DAYSMAT
- MATURITY

PRODUCTION

- ADFLEAF
- ADFSTEM
- NDFLEAF
- NDFSTEM
- SDLGYRYLD
- SEEDPROD
- STEMLFRAT

STRESS

- ACIDSOIL
- FROSTDAM
- SALTGERM
- SALTSTRESS
- WINTERINJ

- CHECKS
- CORE

UCD ALFALFA WORKGROUP

GRIN Crop-specific Query
Query conditions:
Crop: ALFALFA
SALTGERM less than -0.6
SALTSTRESS greater than 0.85

Accessions meeting criteria:

1. PI 145202
2. PI 163107 No. 8361
3. PI 164415 No. 8708
4. PI 167068 No. 265
5. PI 170535 YONCA
6. PI 170536 KAYSERI
7. PI 170551 YONCA
8. PI 172188 CURIBAYA
9. PI 172189 FEWAN
10. PI 172985 No. 8387
11. PI 174881 No. 9892

303. PI 516879 GR767

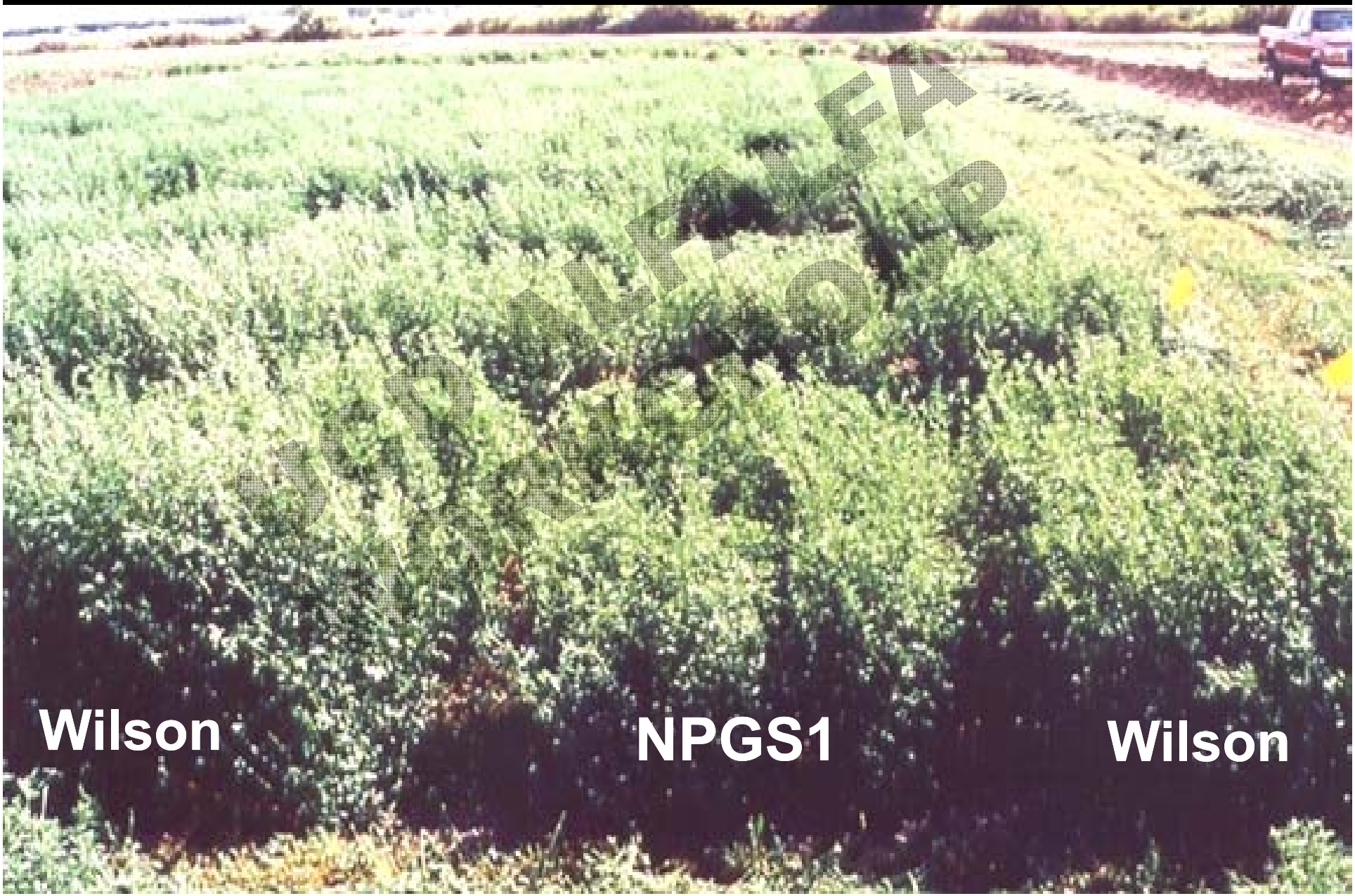
USDA ALFALFA WORKGROUP

303 POPULATIONS IDENTIFIED

Divided into 4 dormancy groups

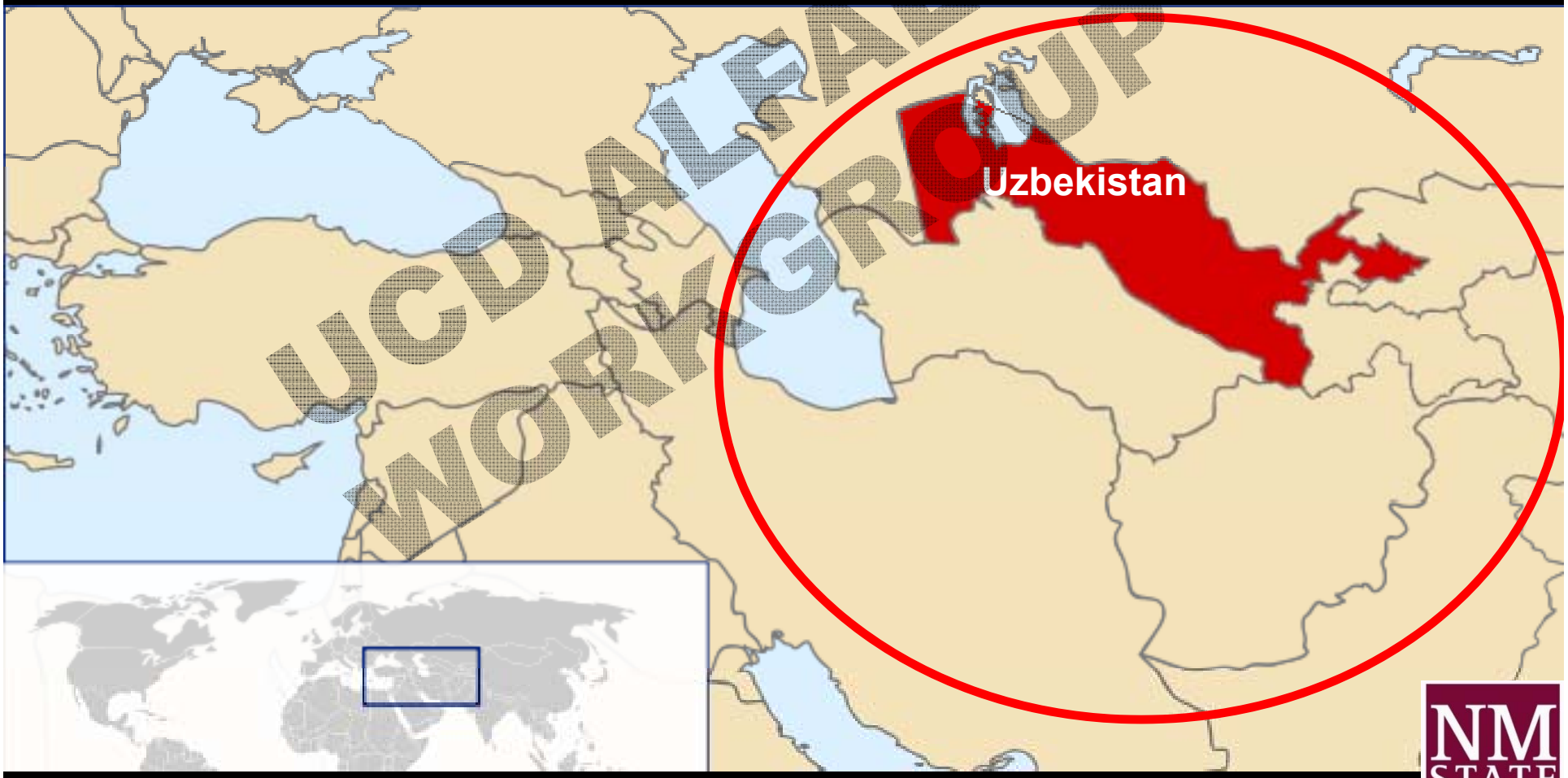
- **FD1-3**
- **FD4-5**
- **FD6-7**
- **FD8-10**

NPGS POPULATIONS EVALUATED IN FOUR DORMANCY GROUPS WITH ALTERNATING CHECK PLOTS



DEFICIT IRRIGATION (one irrigation/cut)
4 to 6 CUTS PER YEAR OVER 2 YEARS

CONCLUSION: SEMI- AND NON-DORMANT POPULATIONS FROM CENTRAL ASIA APPEAR TO BE MOST USEFUL FOR IMPROVING ALFALFA PRODUCTIVITY UNDER DEFICIT IRRIGATION



Source: http://en.wikipedia.org/wiki/File:LocationUzbekistan

NM STATE

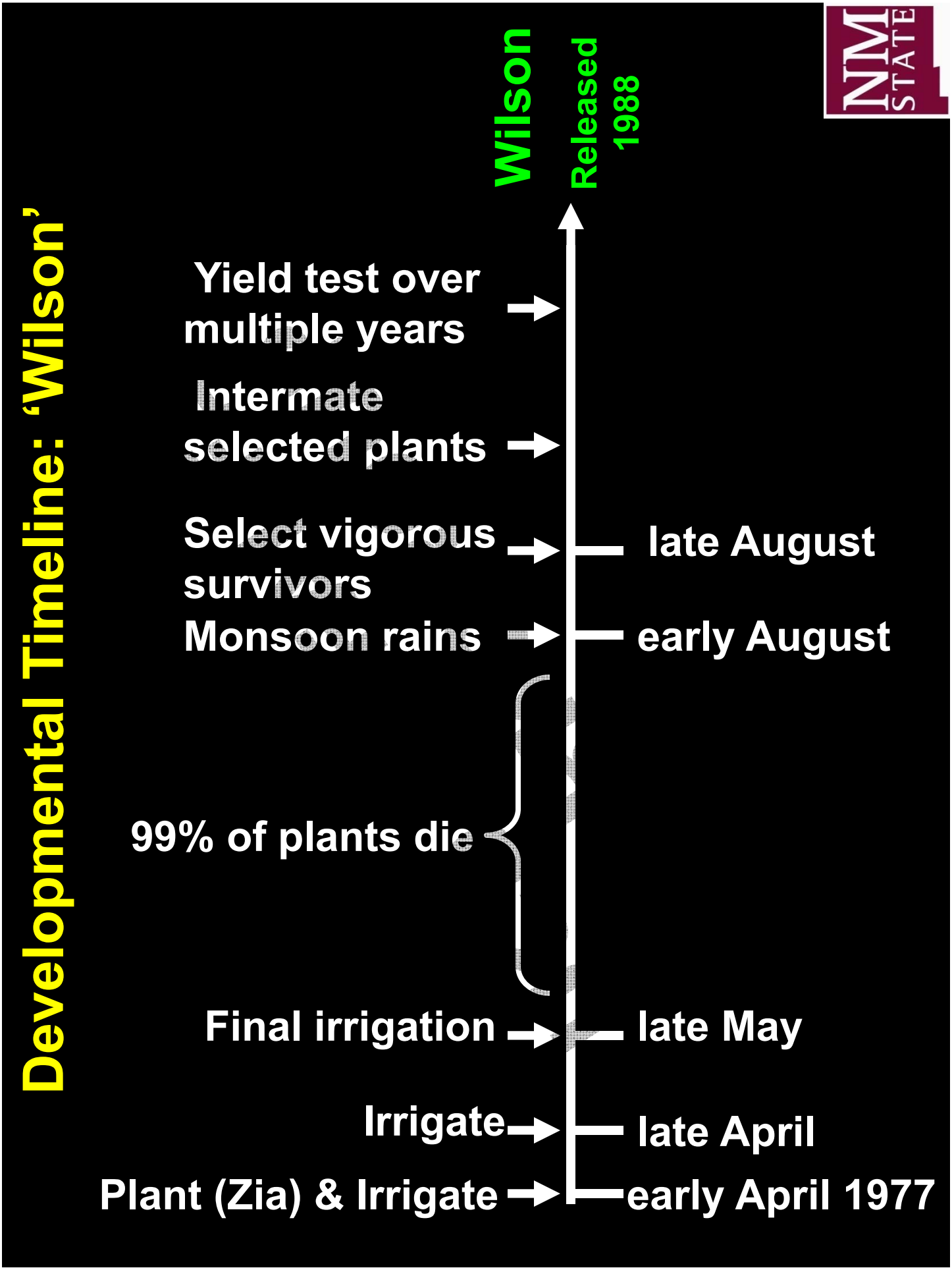
DROUGHT TOLERANT CULTIVAR DEVELOPMENT

‘WILSON’ ALFALFA

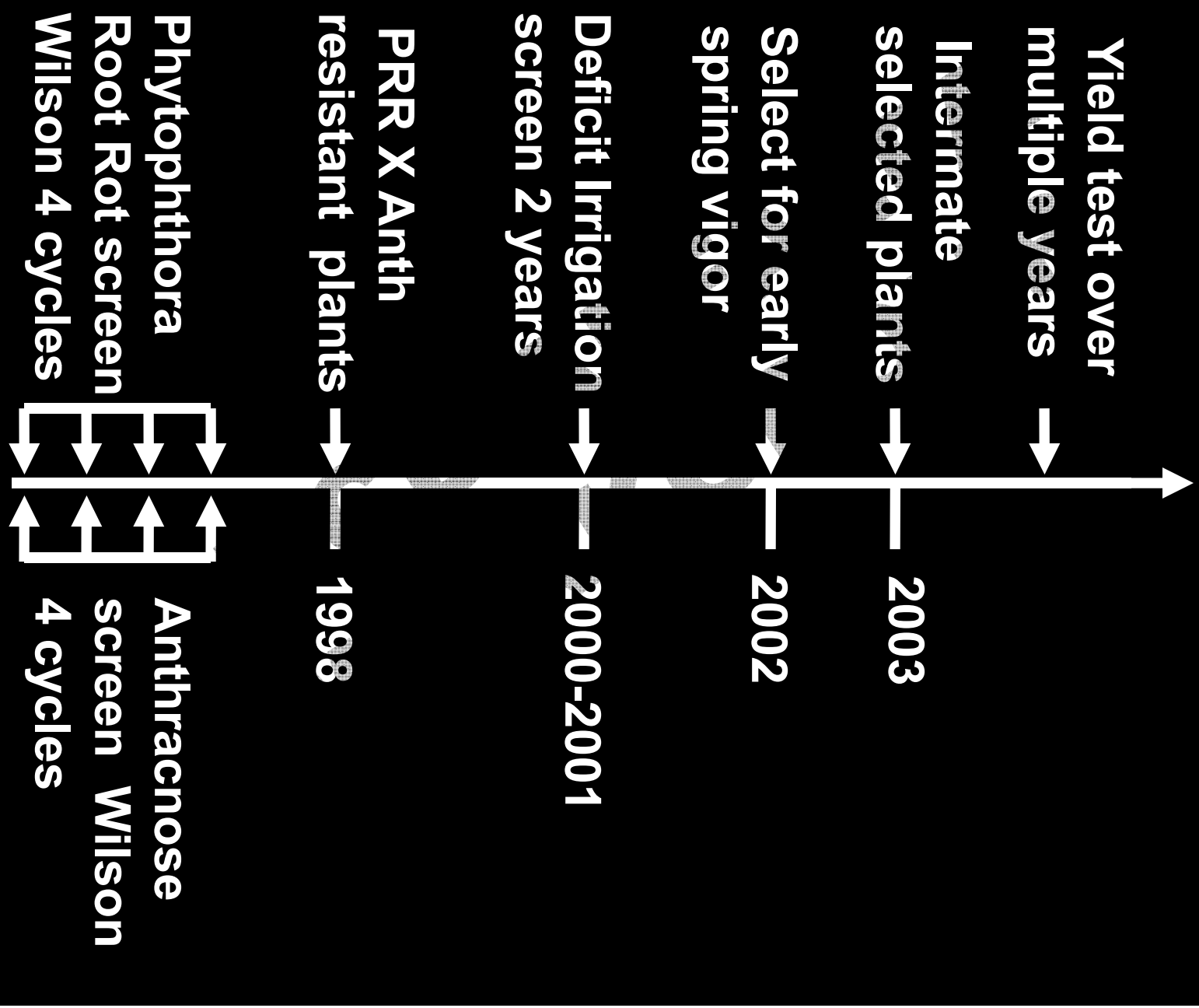
‘NUMEX BILL MELTON’ ALFALFA

NM STATE

Agriculture
Experiment Station


Developmental Timeline: 'Wilson'
Wilson
Released
1988
Yield test over multiple years
Intermate selected plants
Select vigorous survivors
late August
Monsoon rains
early August
99% of plants die
Final irrigation
late May
Irrigate
late April
Plant (Zia) & Irrigate
early April 1977

Developmental Timeline: 'NuMex Bill Melton'



NuMex Bill Melton Yield Data Collected at Four Locations under Sprinkler or Flood Irrigation Mgmt.

NuMex Bill Melton under variable soil moisture trts:

Among the top performing entries at 4 New Mexico locations.

Yielded 13%, 10%, & 5% greater than Wilson, Dona Ana, and 56S82 check cultivars.

Slower establishment due to root system development????

Yield Performance of NuMex Bill Melton Relative to Wilson and Dona Ana (%)

	Year 1		Year 2		Year 3		Year 4		Average	
Location	Wilson	Dona Ana	Wilson	Dona Ana	Wilson	Dona Ana	Wilson	Dona Ana	Wilson	Dona Ana
Las Cruces										
Normal	12%	17%	17%	7%	25%	9%	23%	9%	19%	11%
Drought†	10%		2%		11%				8%	
Artesia										
Normal	3%	-10%	18%	15%	0%	0%			7%	1%
Drought†	-1%	0%	11%	28%	18%	9%			10%	13%
Clovis										
Normal	-3%	-7%	9%	4%	8%	4%	8%	11%	5%	2%
Farmington										
Normal	26%	7%	18%	34%	20%	39%			21%	28%

†50% of standard irrigation rate

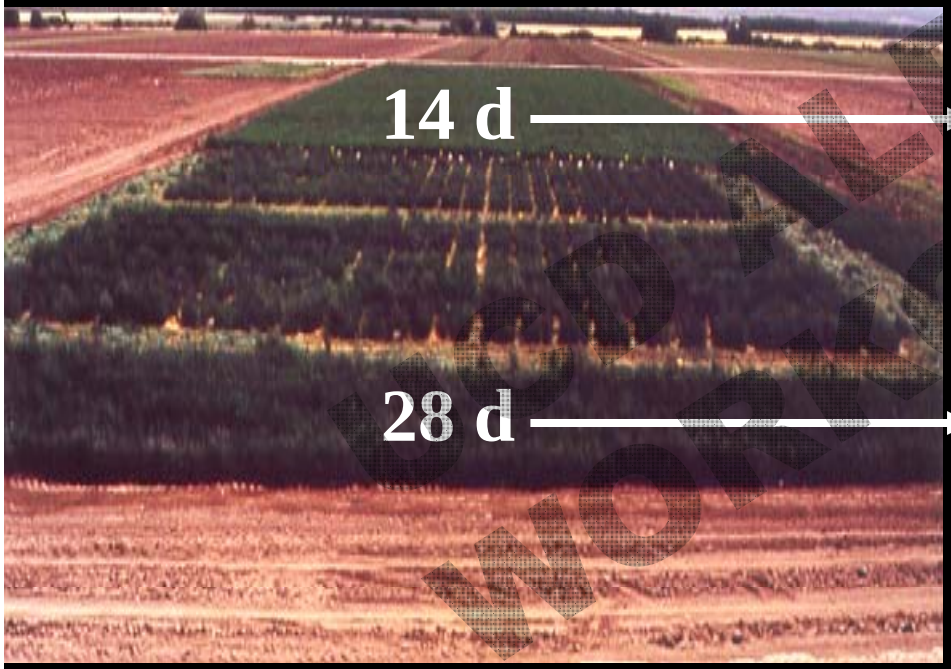
UC ALFALFA WORKGROUP

UCD ALFALFA
WORKING GROUP

WATER STRESSED ALFALFA PHYSIOLOGY & DEVELOPMENT STUDIES

Agriculture
Experiment Station

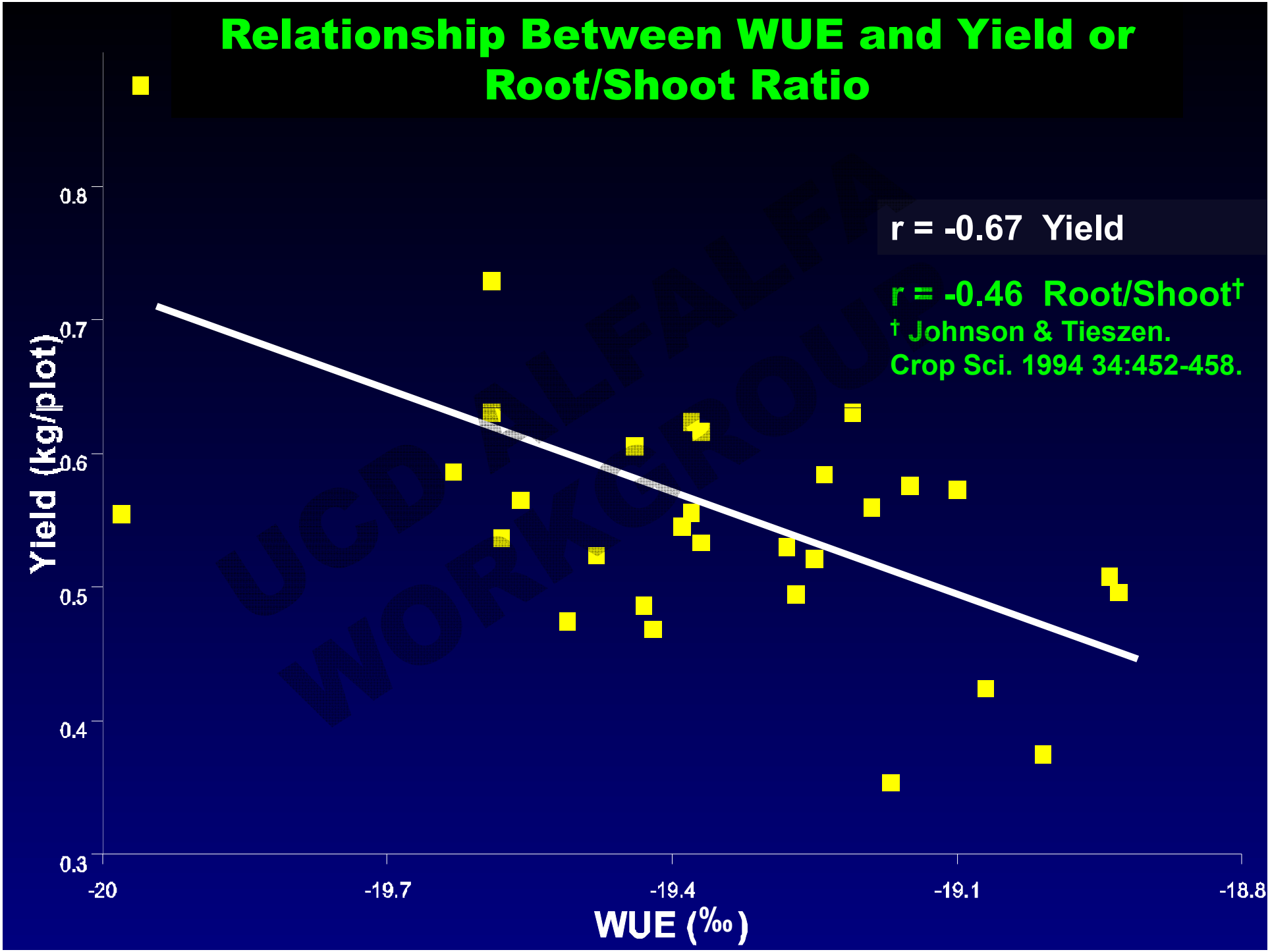
Alfalfa Evaluation Under 14d and 28d Irrigation Intervals



NM STATE

Traits measured: Yield, leaf/stem ratio, maturity, leaf thickness, canopy temp., water-use efficiency.

Relationship Between WUE and Yield or Root/Shoot Ratio



UCD ALFALFA WORKGROUP

Means over 2 years (July regrowth period) for leaf/stem ratio and specific leaf mass among eight alfalfa germplasms.

PopIn	Leaf/Stem Ratio (%)	Spec. Leaf Mass mg cm^{-2}
African	79.3bc	4.41cd
Chilean	75.6c	4.54bc
Flemish	82.1abc	4.31de
Indian	82.4abc	4.75a
Ladak	90.3a	4.48bcd
M. varia	85.6ab	4.62ab
Peruvian	81.4abc	4.49bcd
Turkistan	75.3c	4.19e

UCD ALFALFA WORKGROUP

CONCLUSIONS:

Under deficit flood irrigation, higher yielding populations:

- **May develop more extensive root systems**
  - **More thoroughly explore the soil profile for available moisture**
  - **Support shoot growth/biomass over an extended period of time.**
- **May possess less leaf mass**
  - **Impact on transpiration rate?**
  - **Impact on forage quality?**

IDENTIFYING DNA MARKERS ASSOCIATED WITH ALFALFA PRODUCTIVITY UNDER DEFICIT IRRIGATION

Collaborator:

Samuel Roberts Noble Foundation

Ardmore, OK

Alfalfa Genetic Mapping Populations

High Water Use Efficiency Low yield

M. sativa ssp. *falcata* var Wisfal

×

Low Water Use Efficiency High yield*

M. sativa ssp. *sativa* var. Chilean

F_1

Wisfal BC_1

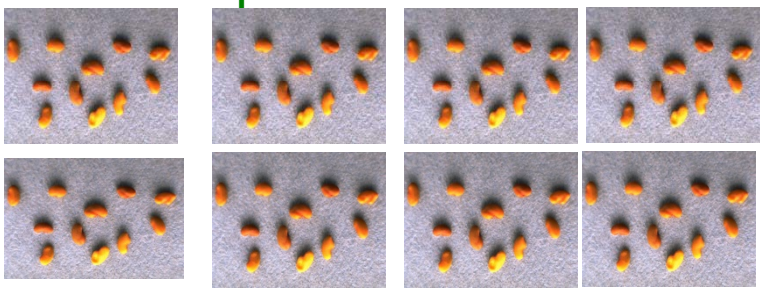
200 genotypes each

Chilean BC_1

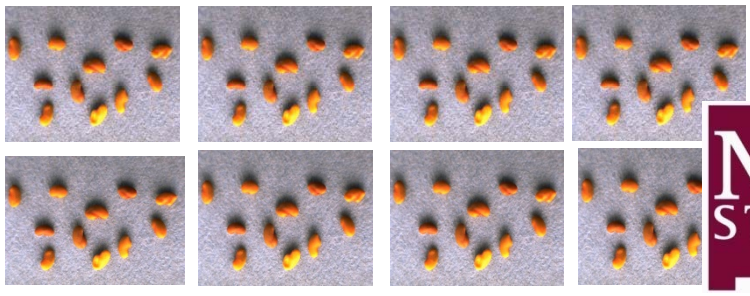
Peruvian Popln Tester

Peruvian Popln Tester

89 $WFBC_1$ half sib families



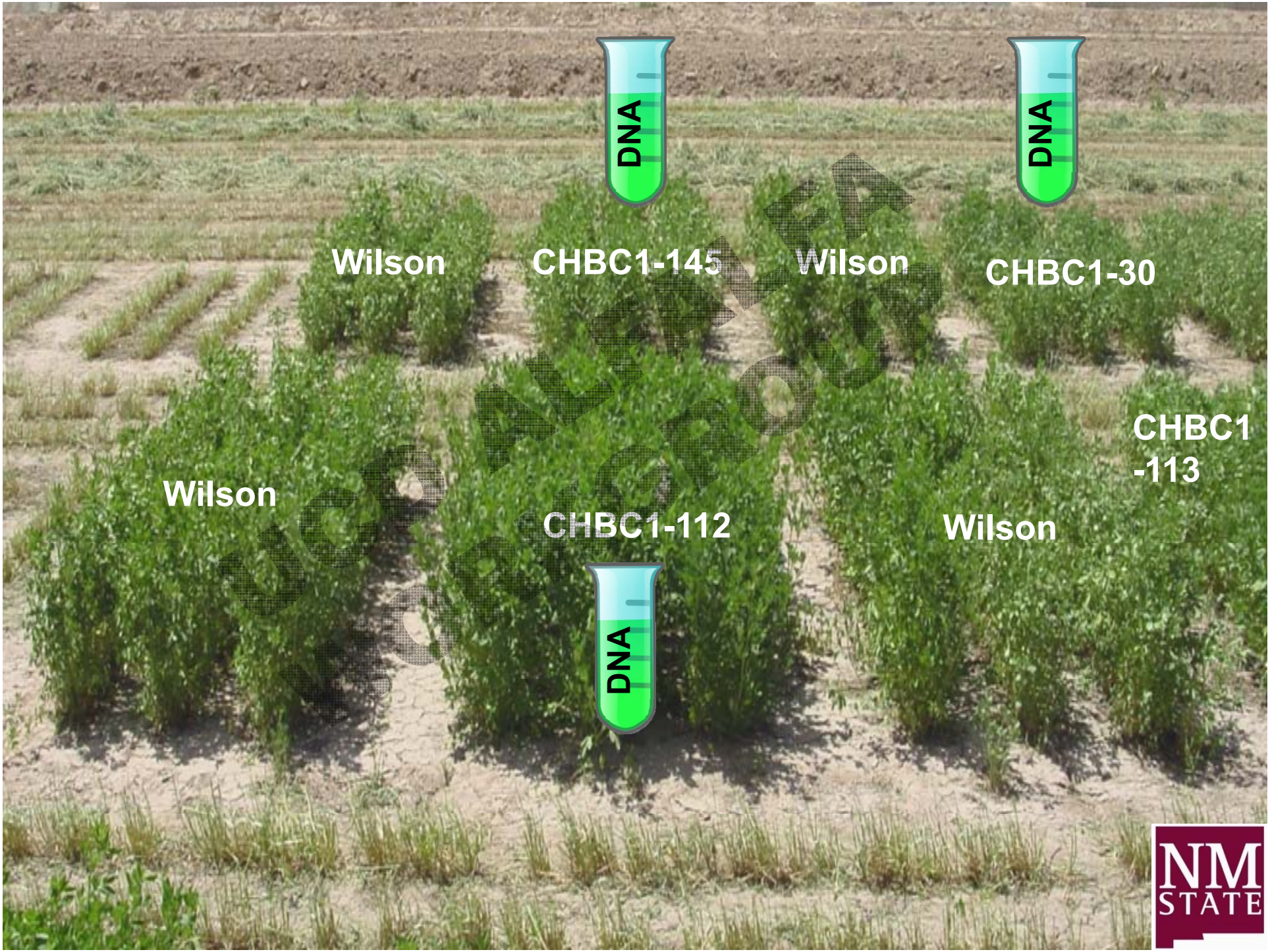
95 $CHBC_1$ half sib families



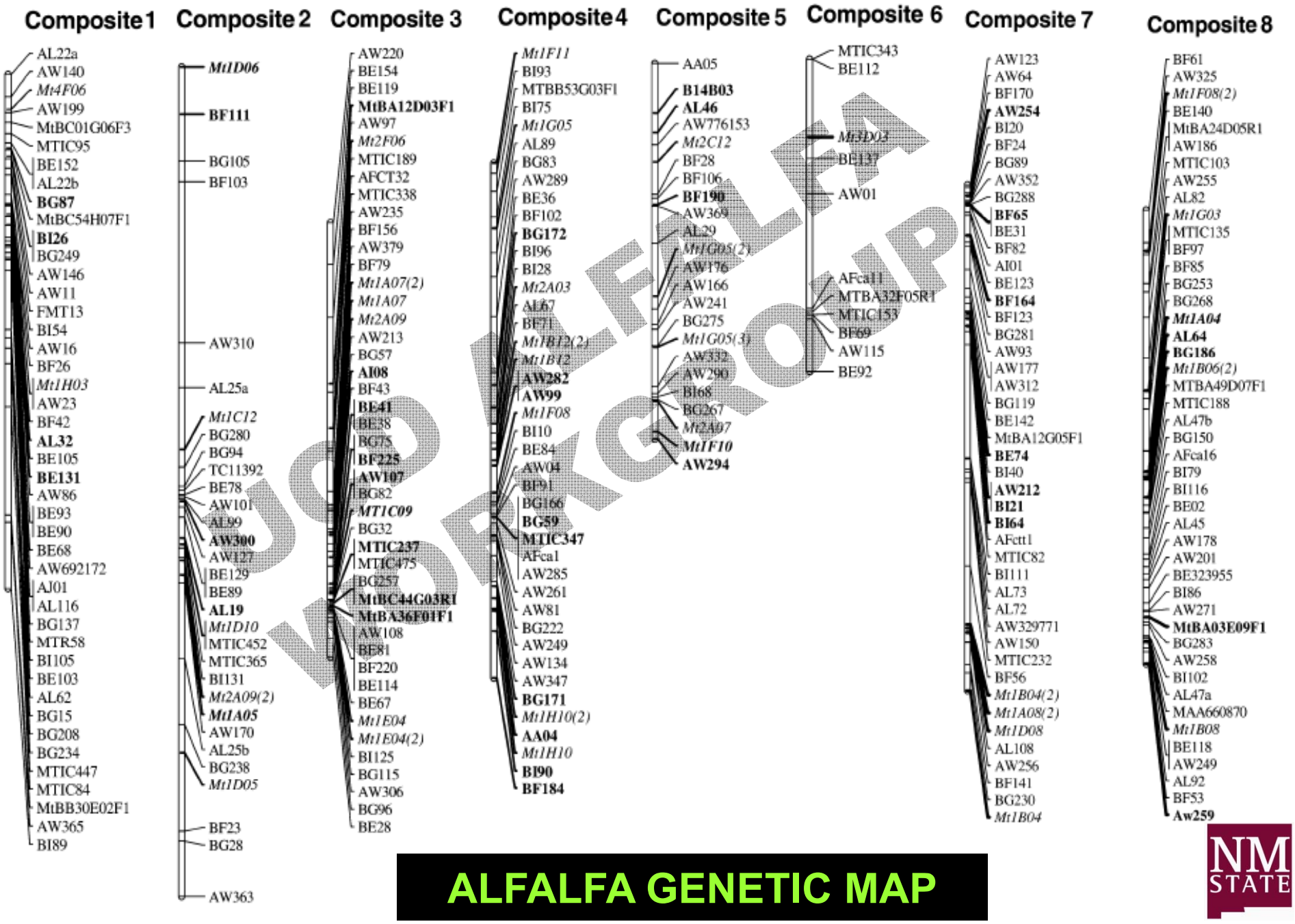
USDA ALFALFA WORKGROUP

NM STATE

USDA ALFALFA
WORKGROUP
NM
STATE


DNA
DNA
Wilson
CHBC1-145
Wilson
CHBC1-30
Wilson
CHBC1
-113
CHBC1-112
Wilson
DNA
UC ALFALFA
IMPROVEMENT
NM
STATE

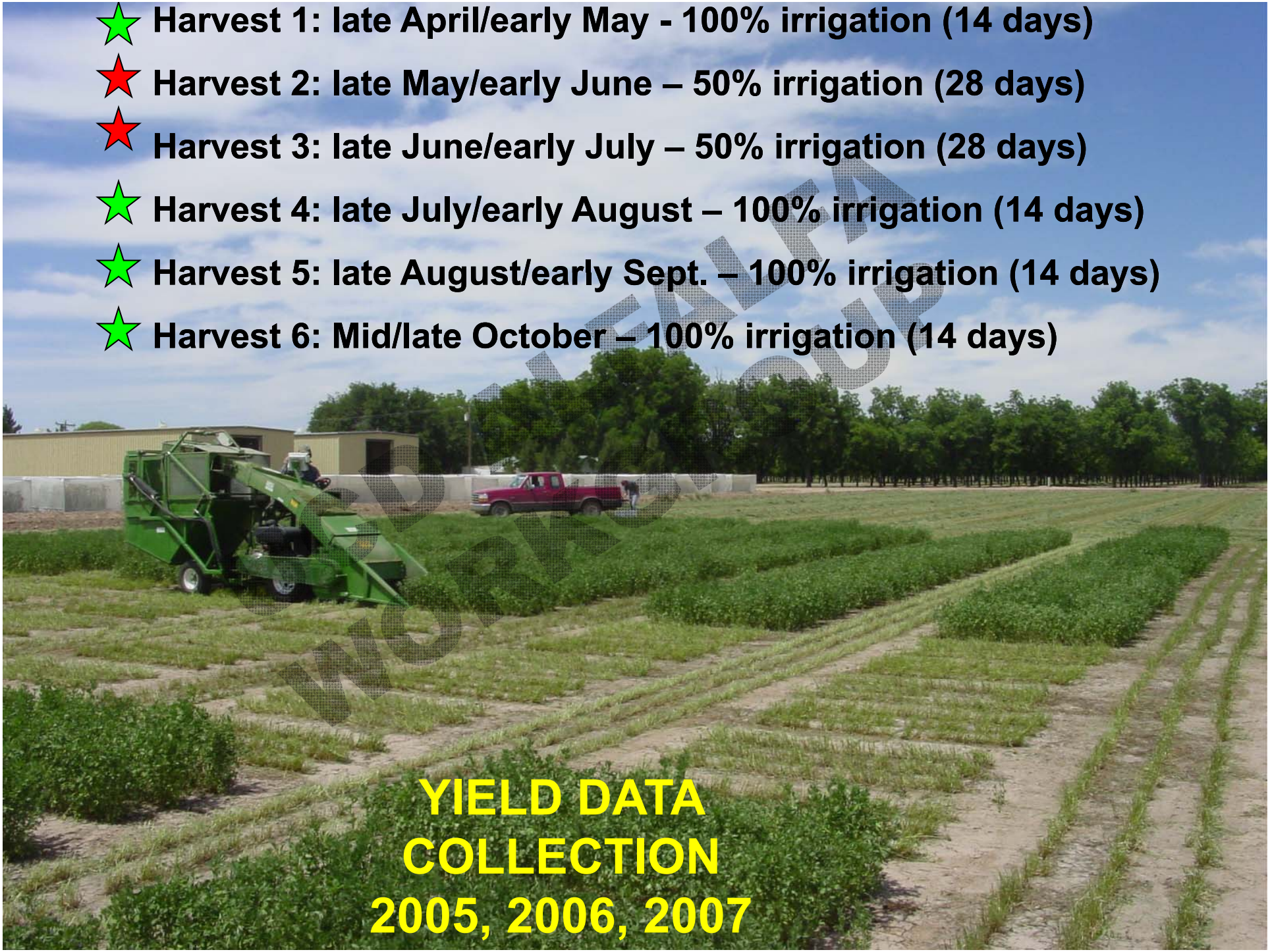
LOCATING 350 DNA MARKERS TO ALFALFA'S 8 CHROMOSOMES



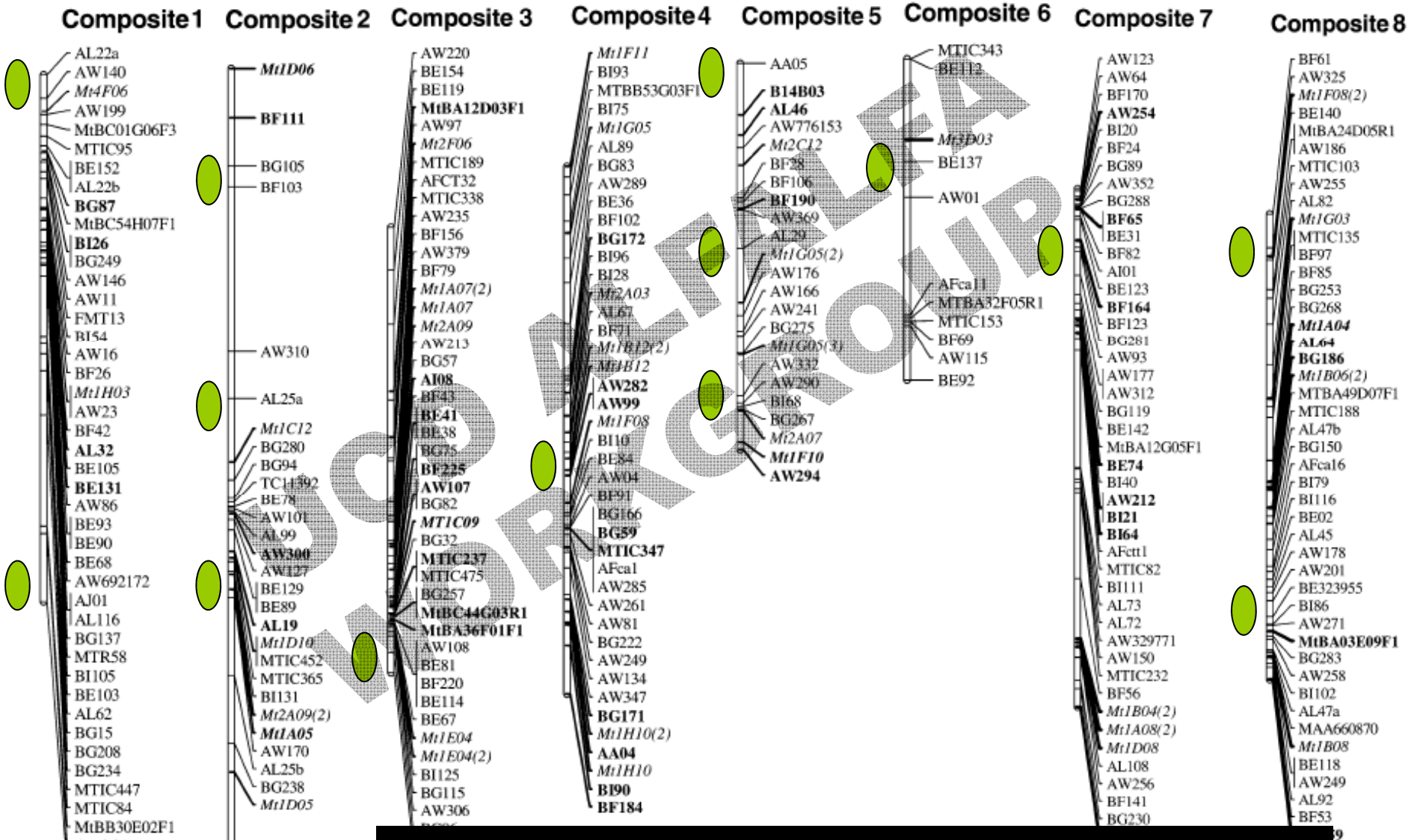
USDA ALFALFA WORKGROUP

ALFALFA GENETIC MAP

NM STATE


Harvest 1: late April/early May - 100% irrigation (14 days)
Harvest 2: late May/early June – 50% irrigation (28 days)
Harvest 3: late June/early July – 50% irrigation (28 days)
Harvest 4: late July/early August – 100% irrigation (14 days)
Harvest 5: late August/early Sept. – 100% irrigation (14 days)
Harvest 6: Mid/late October – 100% irrigation (14 days)
YIELD DATA
COLLECTION
2005, 2006, 2007

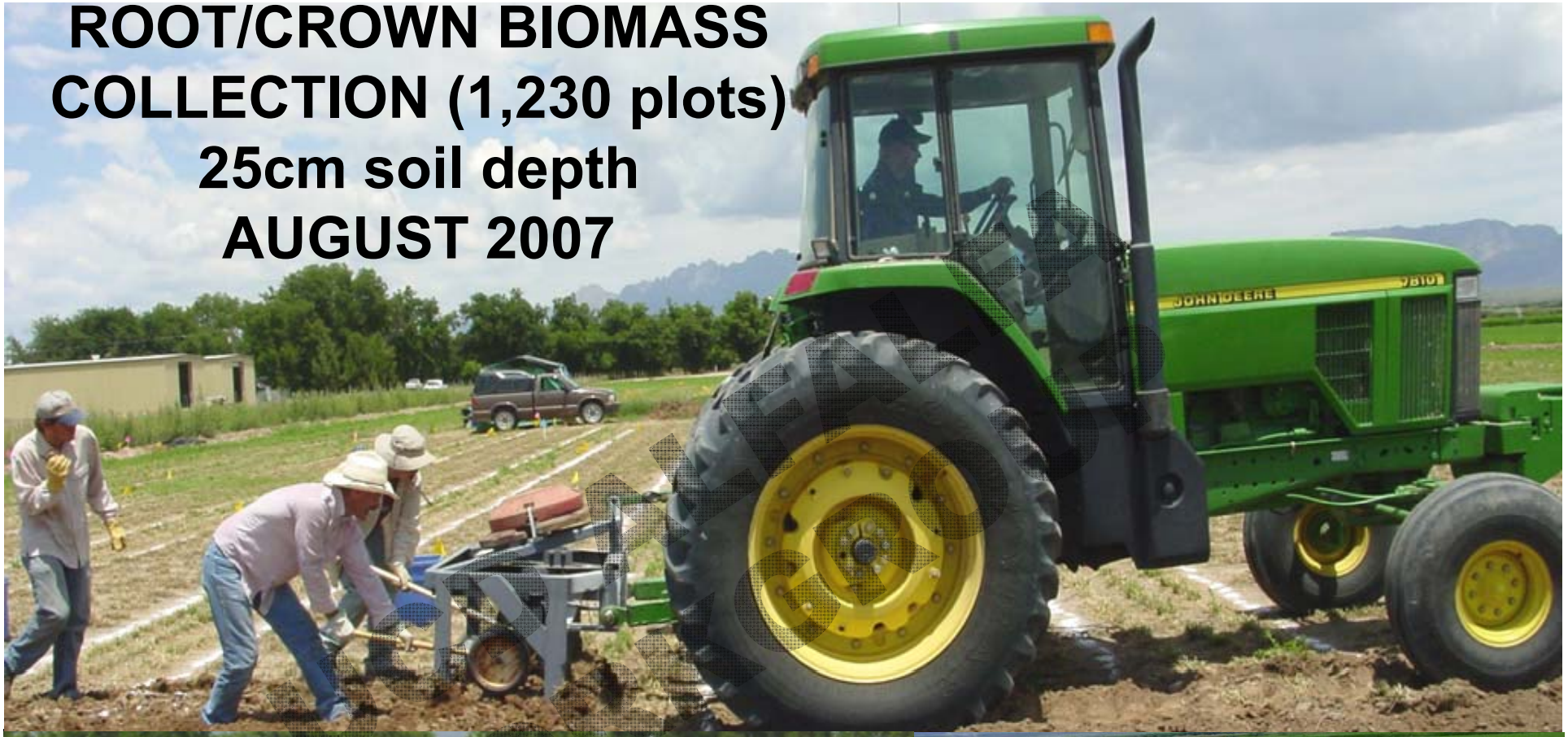
LOCATING DNA MARKERS/GENES ASSOCIATED WITH BIOMASS PRODUCTION UNDER WATER DEFICIT



DO ALFALFA WORKGROUP

NM STATE

ROOT/CROWN BIOMASS COLLECTION (1,230 plots)
25cm soil depth
AUGUST 2007



DEPLOYING "DROUGHT PRODUCTIVITY" DNA MARKERS INTO ALFALFA CULTIVARS

In progress

Collaborator:

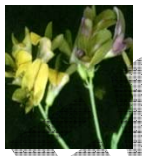
Dr. Francisco Contreras-Govea – NMSU Artesia

DNA MARKER ASSISTED SELECTION

High WUE
Low yield

Low WUE
High yield*

Wisfal 1♀ × Chilean 28 ♂



MFC192F$_1$ x Malone1 ♀

200 MFC192Malone plants (Full-sibs)

Score all plants with

6 shoot biomass markers

AL22 (+), BE137(+), BE140(+) = HSY1 PopIn

AW86(+) = HSY2 PopIn

BF228(-), AL29 (-) = LSY PopIn

4 root biomass markers

AW256 (+), AFca11 (+) = HRY PopIn

MTIC103 (-), BG57 (-) = LRY PopIn

UCD ALFALFA WORKGROUP

NM STATE

DEPLOYING MARKERS INTO CULTIVARS

3 CULTIVARS SELECTED

Malone, Multileaf1, NuMex Bill Melton

20 HSY1 plants x 3 cultivars→ 3 HSY1/CULTIVAR poplns
20 HSY2 plants x 3 cultivars→ 3 HSY2/CULTIVAR poplns
20 LSY plants x 3 cultivars→ 3 LSY/CULTIVAR poplns

20 HRY plants x 3 cultivars→ 3 HRY/CULTIVAR poplns
20 LRY plants x 3 cultivars→ 3 LRY/CULTIVAR poplns

+ 17 other poplns (e.g. parent poplns, controls, etc.)

TOTAL = 32 POPULATIONS PLANTED OCT. 2010

NM STATE

ANTICIPATED OUTCOMES OF THIS PROJECT

Hypothesis 1: Forage yield of "leafy" culitvar will be more sensitive to water-stress.

Why? Greater leaf percentage→increased transpiration rate → rapid soil moisture depletion→water stress→yield loss???

Hypothesis 2: Forage quality deterioration under deficit irrigation will be greater in standard & multi-leaf cultivars than in drought tolerant cultivars.

Why? Drought sensitivity → stress-induced leaf & shoot senescence→ decreased nutritive content????

Hypothesis 3: HSY or HRY DNA markers will help preserve forage yield and quality of standard and multileaf cultivars during drought stress.

NMSU Alfalfa Team:

Left to Right: Chris Meenach, Austin Ray, Chris Pierce, Nicole Ray, Karen Ray, Irene Calderon, Greg Bettmann, and Mat Pinch.

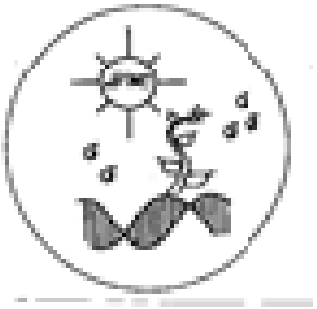
Not pictured: Gina Babb, Lei E, Johnny Maruthavanan, Nina Klypina, Tracy Sterling, Alexis Ray, Hem Singh Bhandari, Rossio Kersey.

UC ALFALFA WORKGROUP

Special Thanks to Noble Fdn Collaborators (Past & Present):
Mary Sledge, Greg May, Joe Bouton, Maria Monteros, YuanHong Han

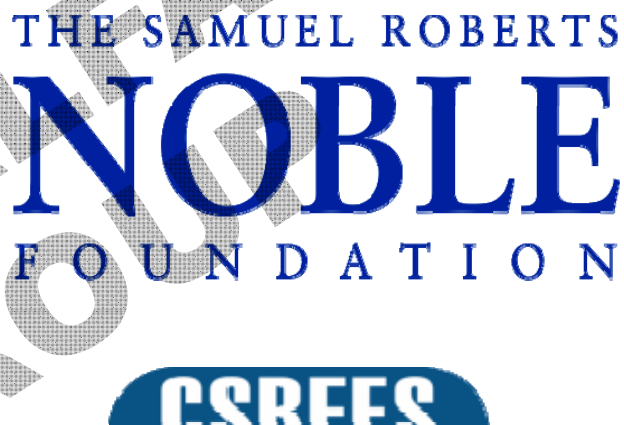
We gratefully acknowledge the following supporters of this research

UCD ALFALFA WORKGROUP



Agriculture
Experiment Station

S.W. Consortium
Plant Genetics & Water Resources



National Research Initiative
Agricultural Plants &
Environmental Adaptation
Program
Award #2005-35100-16268