Feasibility of breeding sugarcane varieties for changing climate

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UNLOCKING THE POTENTIAL OF SUGARCANE

Climate change scenarios

Parameter	Median	P25	P75
Tmean (ºC)	1.7	1.5	1.9
Tmin (ºC)	1.8	1.6	2
Tmax (ºC)	1.8	1.5	2
Frost days (d)	-1.2	-1.8	-0.9
Annual rain (%)	-2.1	-5.4	0.4
5day Rain max (%)	4.5	1.5	7.1
Cons dry days (d)	3.4	-0.2	7.8
Rain MAM (%	-2.1	-6.1	2.8
Rain JAS (%)	-8.8	-15.6	-7.3
Rain SON (%)	-8.8	-16.6	-5.6
Rain DJF (%)	0.6	-2.6	3.7

1. Temperature increases – heat units,

2. Frost days decreases – less frost damage,

3. Annual rainfall decreases = droughts,

4. Maximum rainfall or storms increases,

5. Dry days increases - drought.

*From Abraham

Implications

- Higher temperatures
  - Higher yields?? Higher heat units!?
  - Higher eldana damage
  - Higher smut infection
- Less rainfall and more dry days
  - Higher eldana damage
  - Higher smut spore survival
  - Lower yield
  - Drought tolerance required

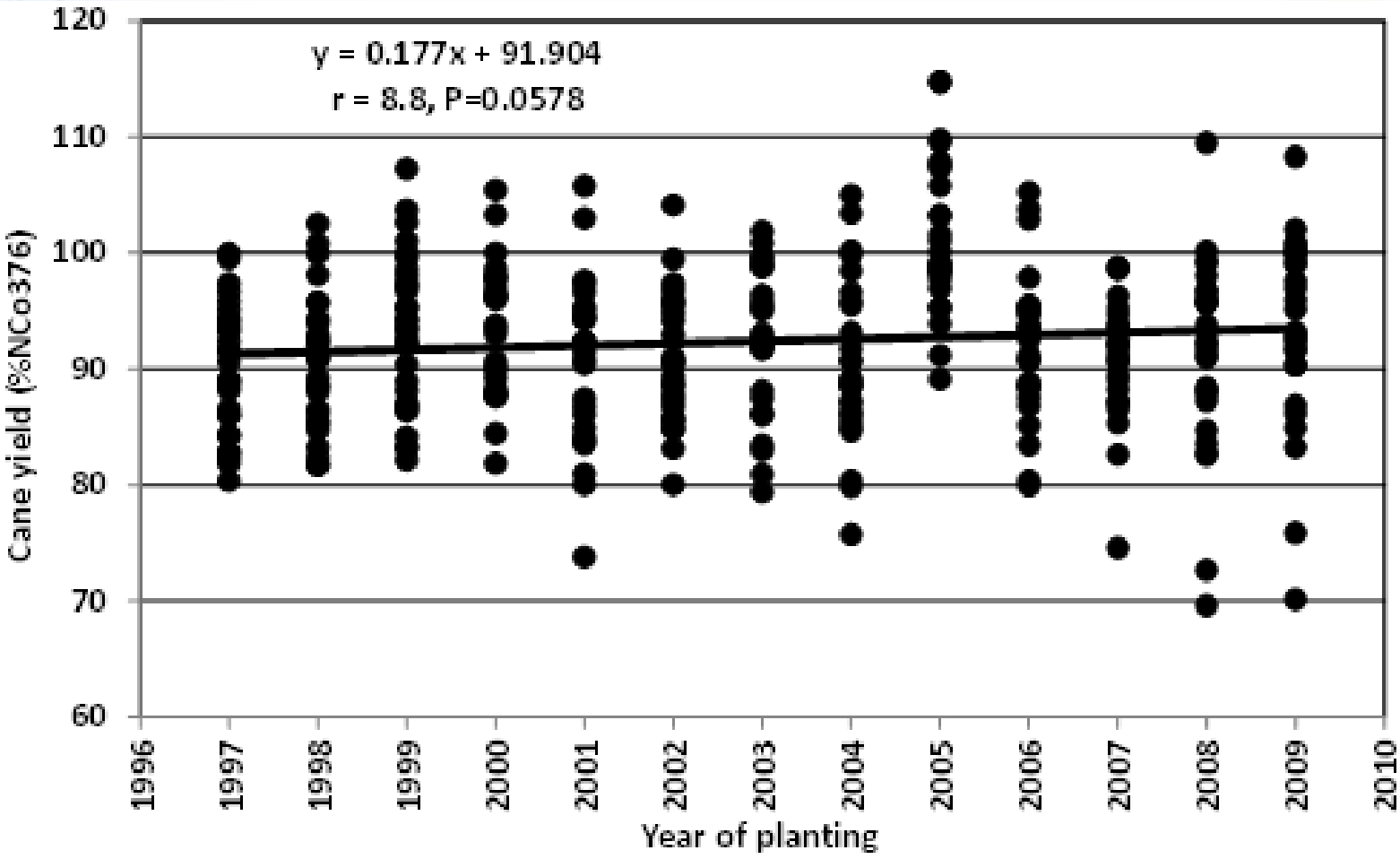
Breeding under these scenarios

- Cane yield
- Sucrose content
- Pests and diseases
  - Eldana
  - Yellow Sugarcane Aphids
  - Smut.

Breeding for cane yield

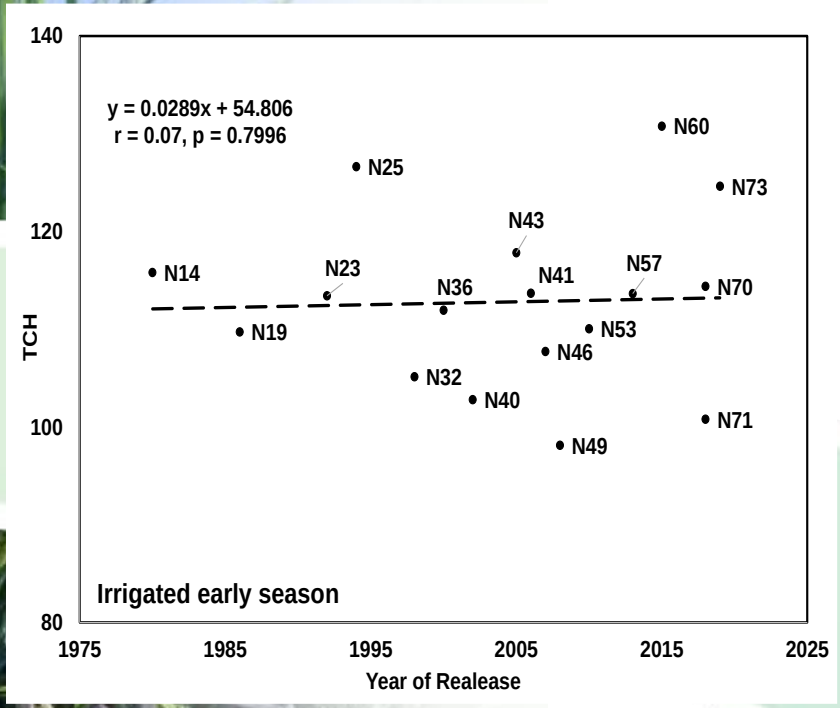
- Can we breed for higher yield under these scenarios?
  - Higher temperatures –
    - higher heat units
    - better growing conditions
    - higher yields
    - Lower harvest age for midlands?
  - Drought stress

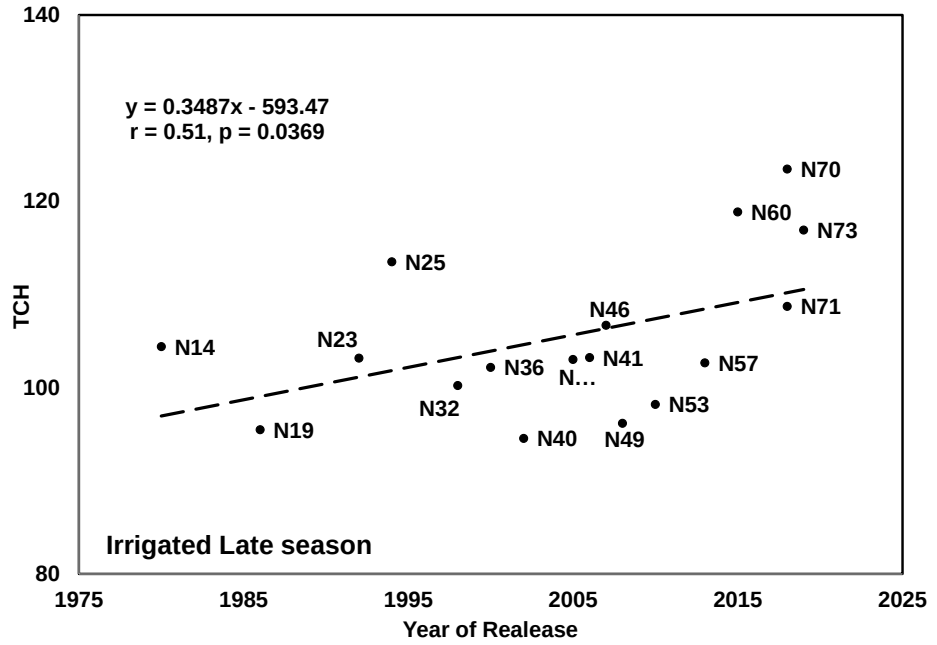
Irrigated – populations



Early and late season confounding

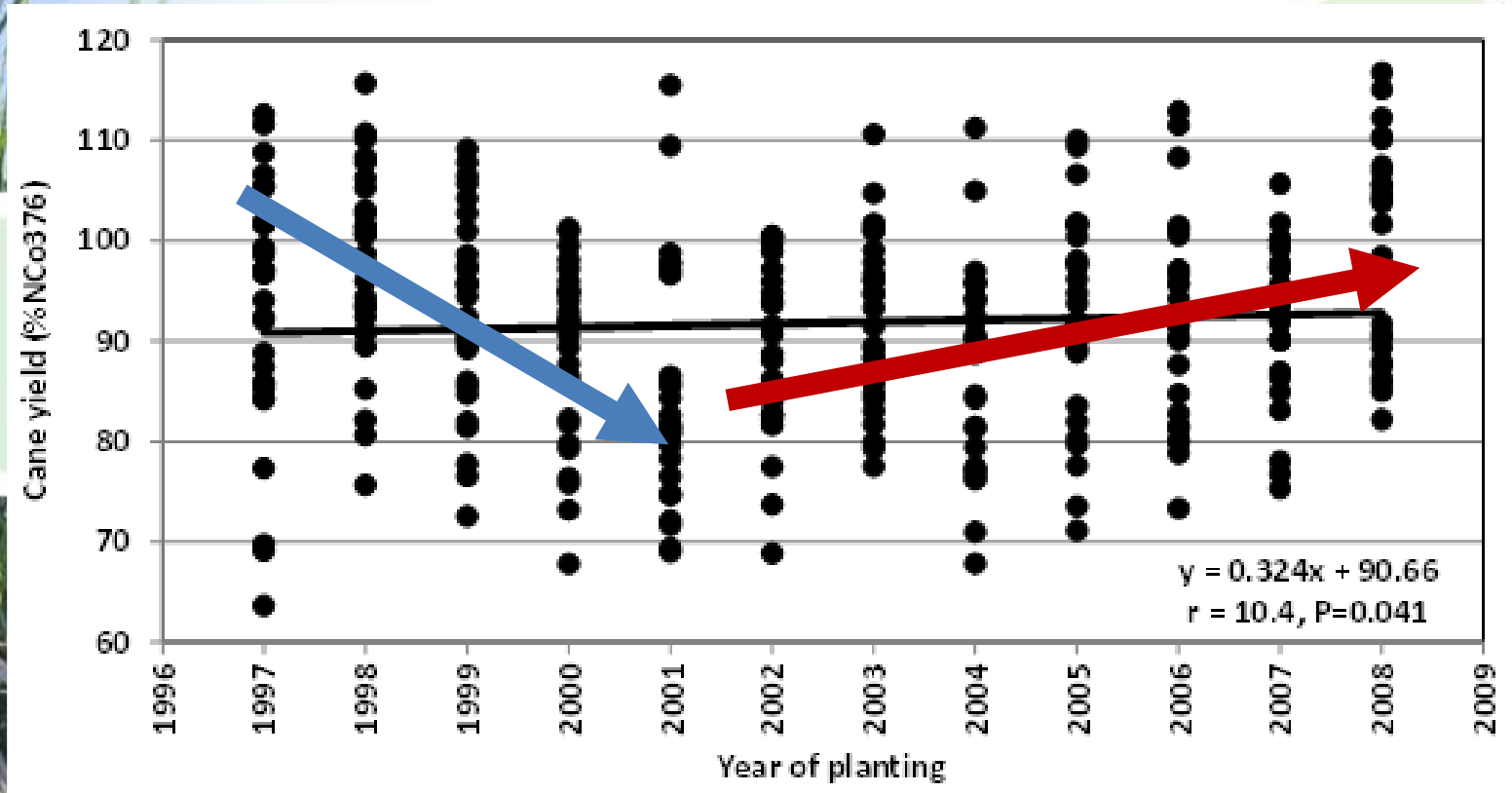
Irrigated - cultivars





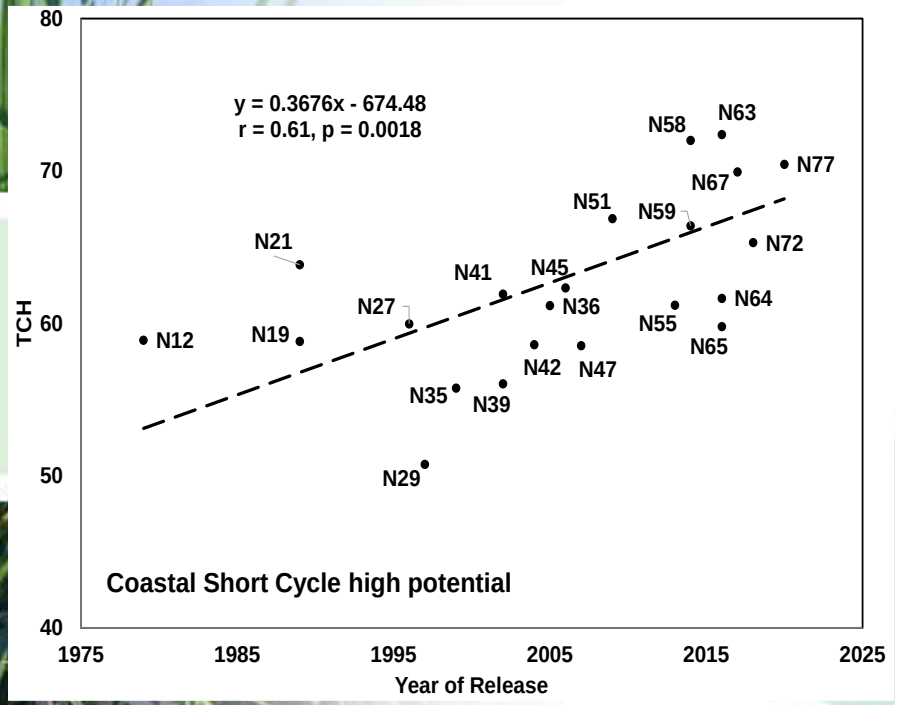
Early stages (1, 2, 3) grown and selected late season

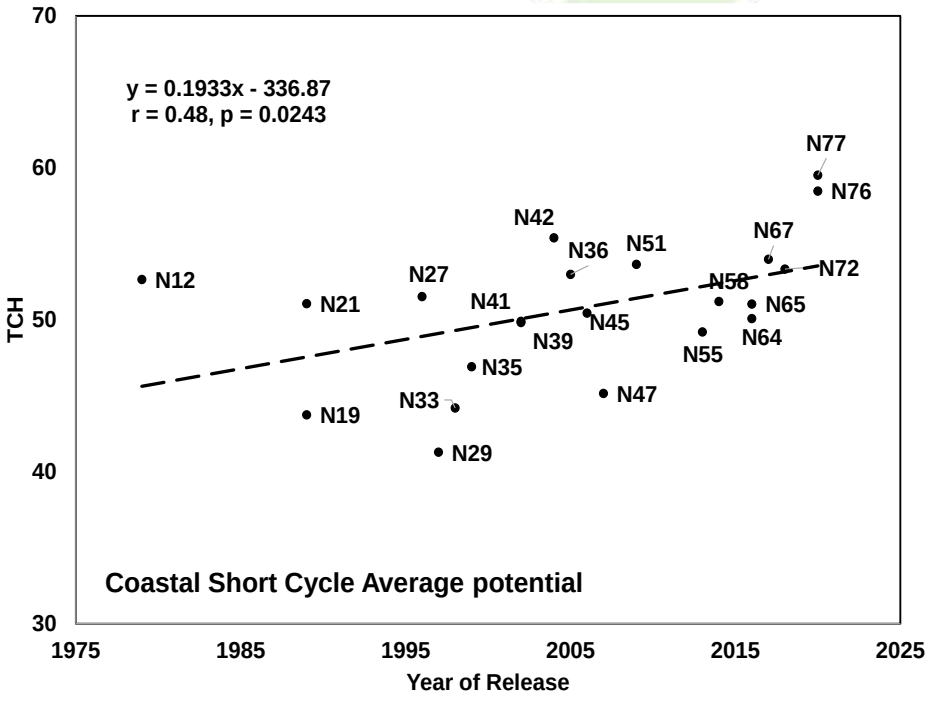
Coastal short cycle populations



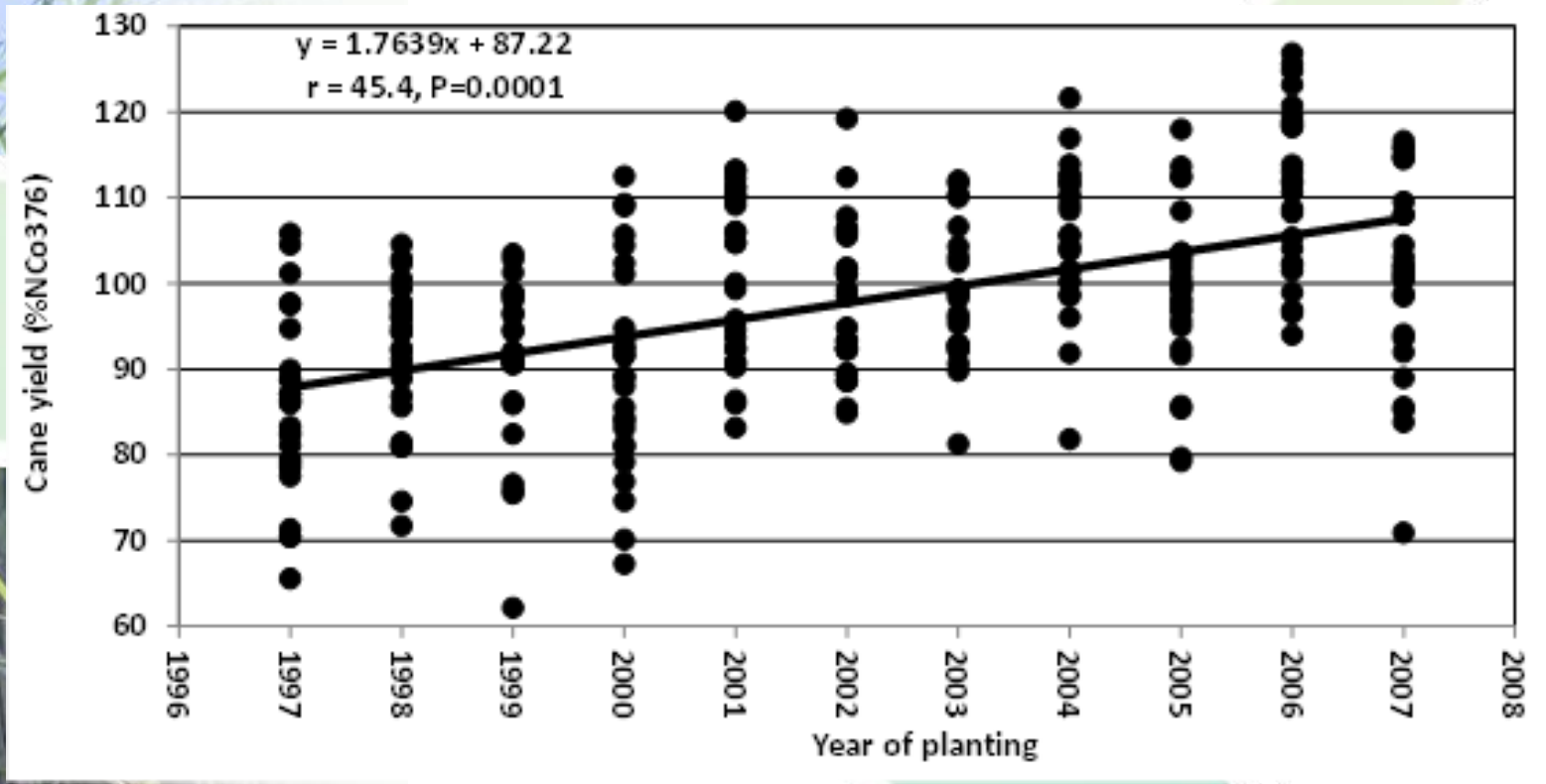
New breeding programme ~ 25 years

Coastal short cycle cultivars

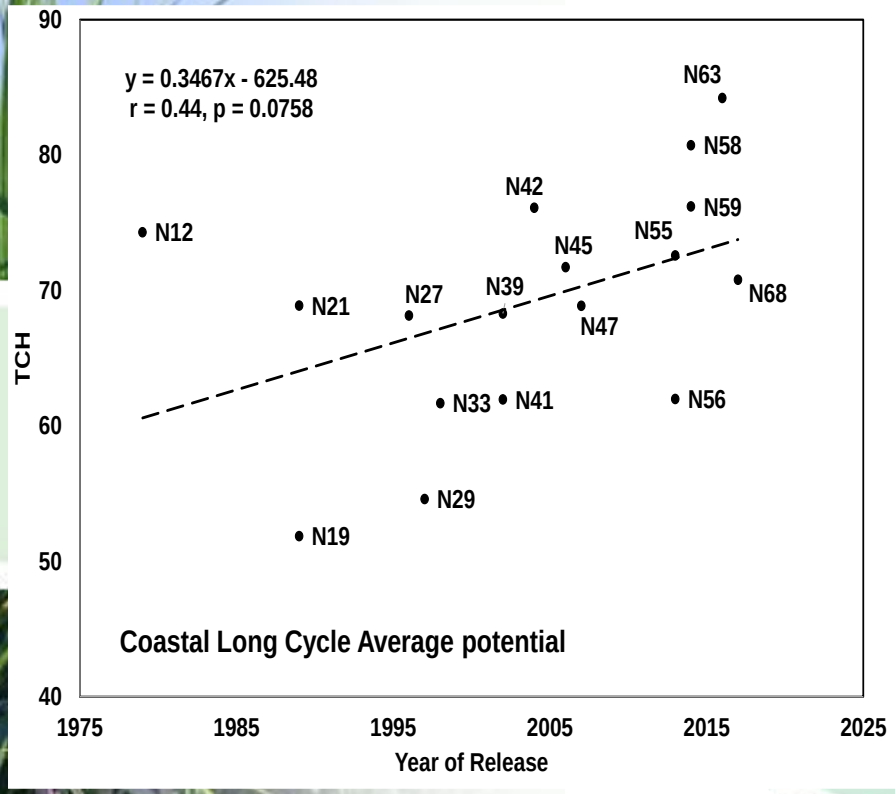


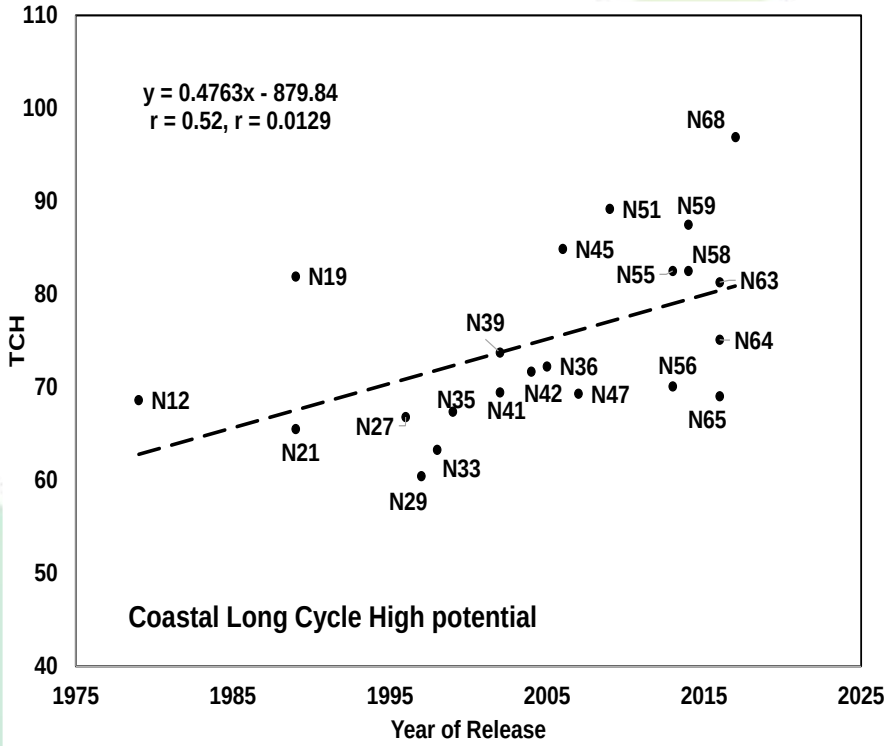


Coastal long cycle populations



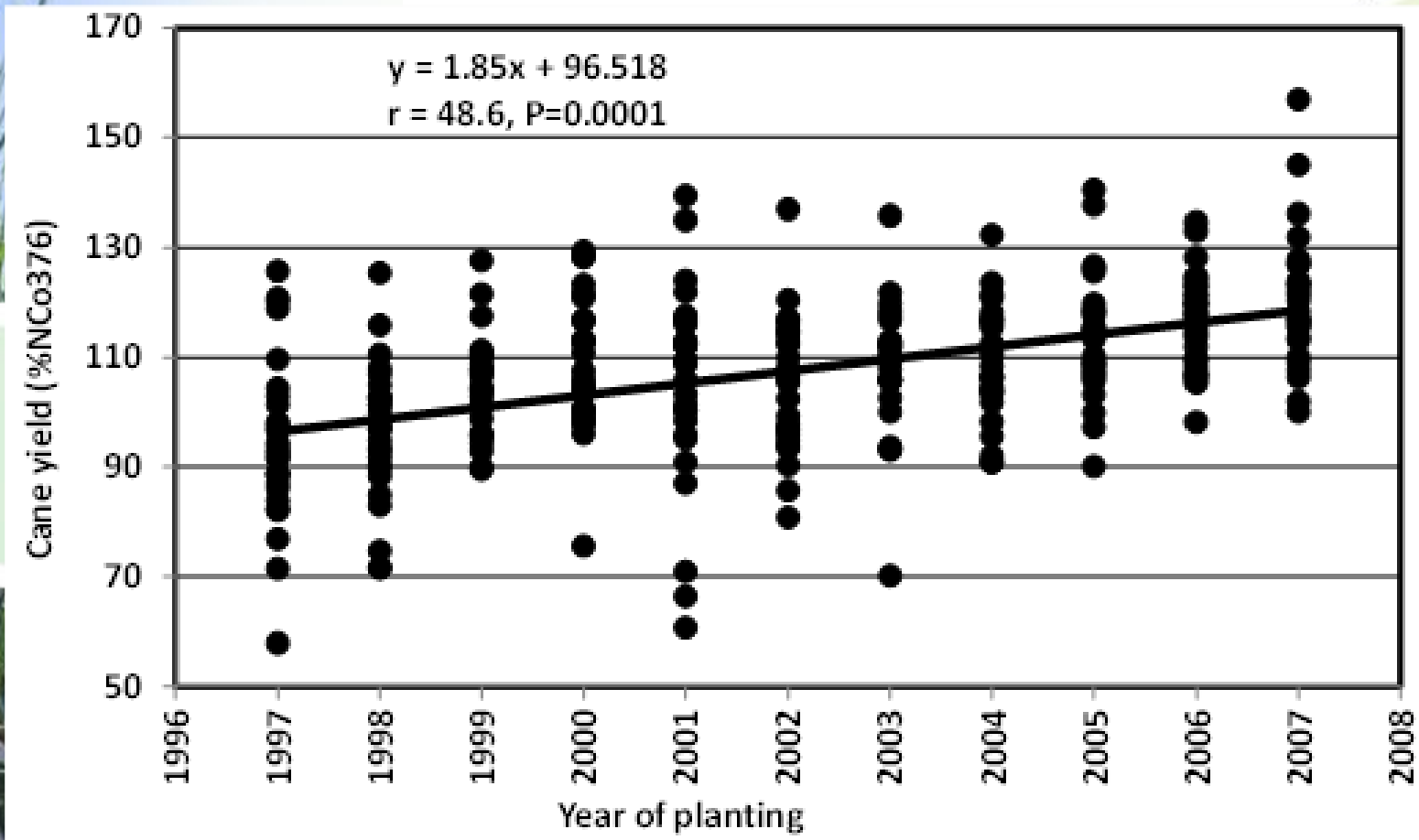
Coastal long cycle cultivars





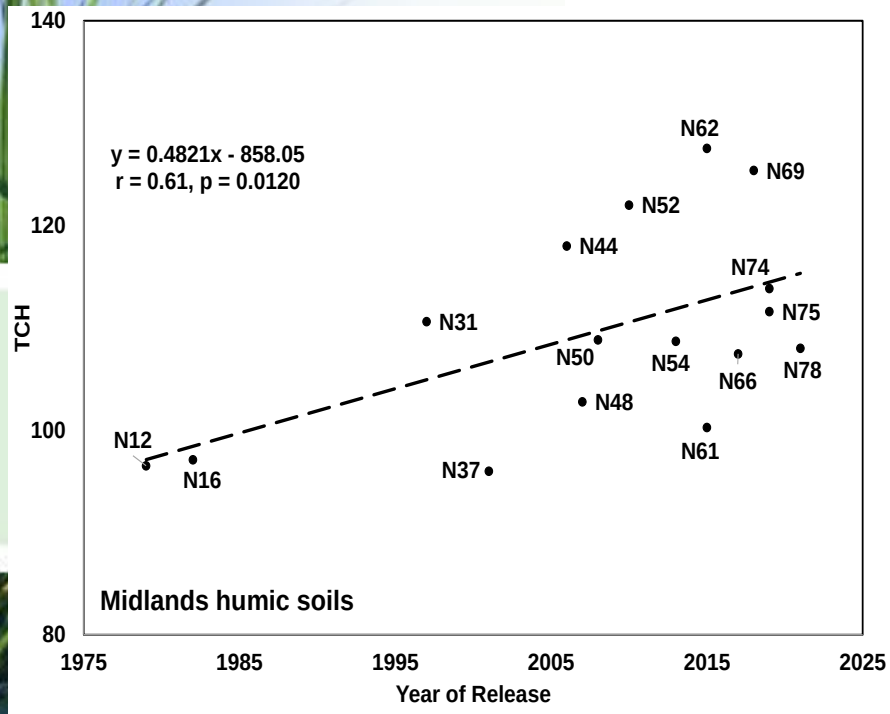
CLCAP = high eldana damage - lower genetic gains,
CLCHP = low eldana damage – higher genetic gains

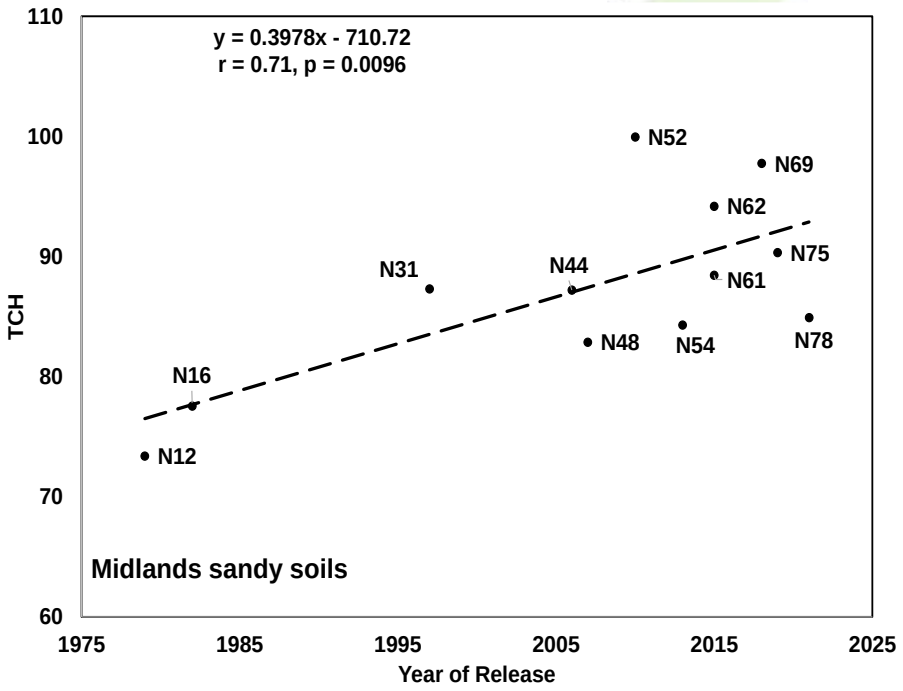
Midlands populations



Low eldana damage + low smut = higher genetic gains, Expected higher eldana damage + higher smut infestation to lower genetic gains

Midlands cultivars

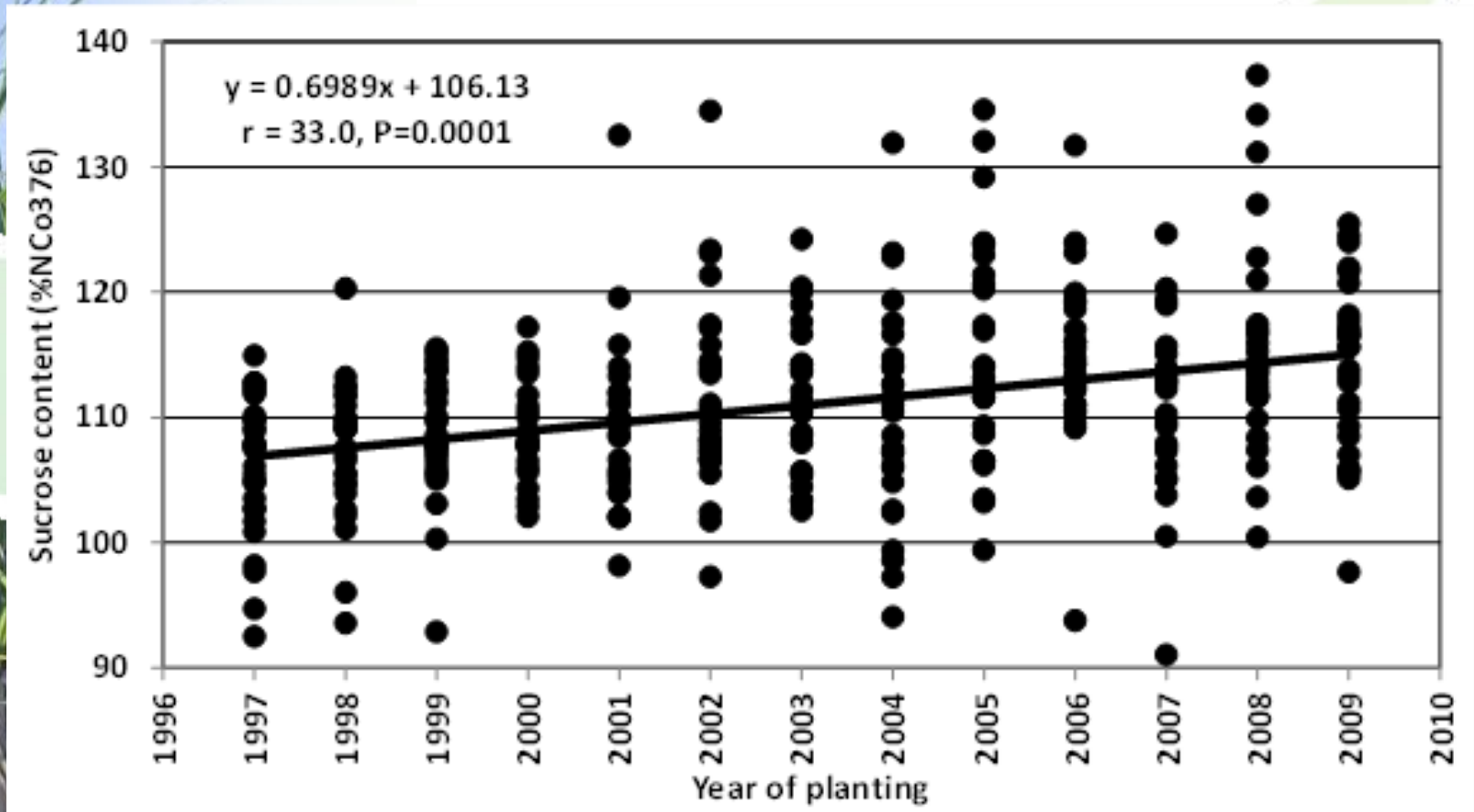




Breeding for Sucrose content

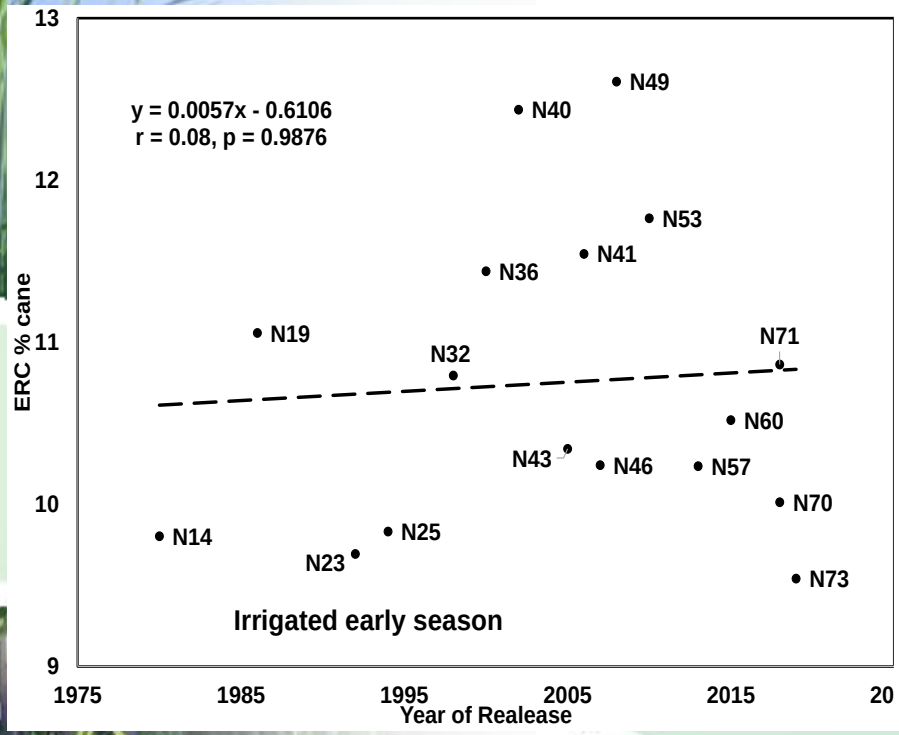
- Higher temperatures
  - higher heat units
  - better growing conditions
  - active growth during harvest
  - lower sucrose content.
- Can we breed for higher sucrose content under these active growing conditions?
- Can we breed for higher sucrose content under drought stress condition?

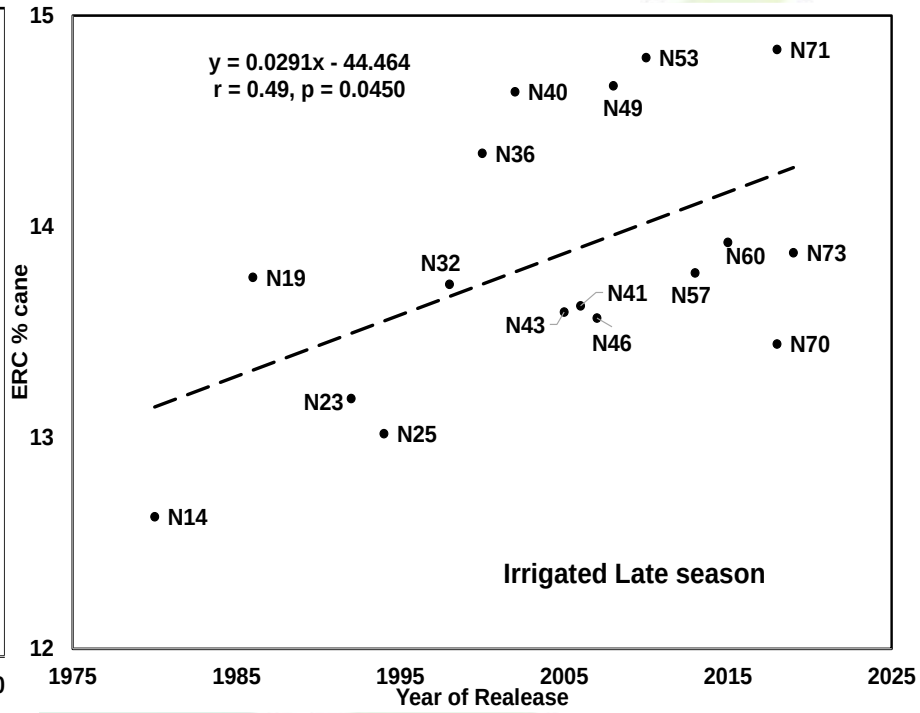
Irrigated populations



Reflects late season confounding

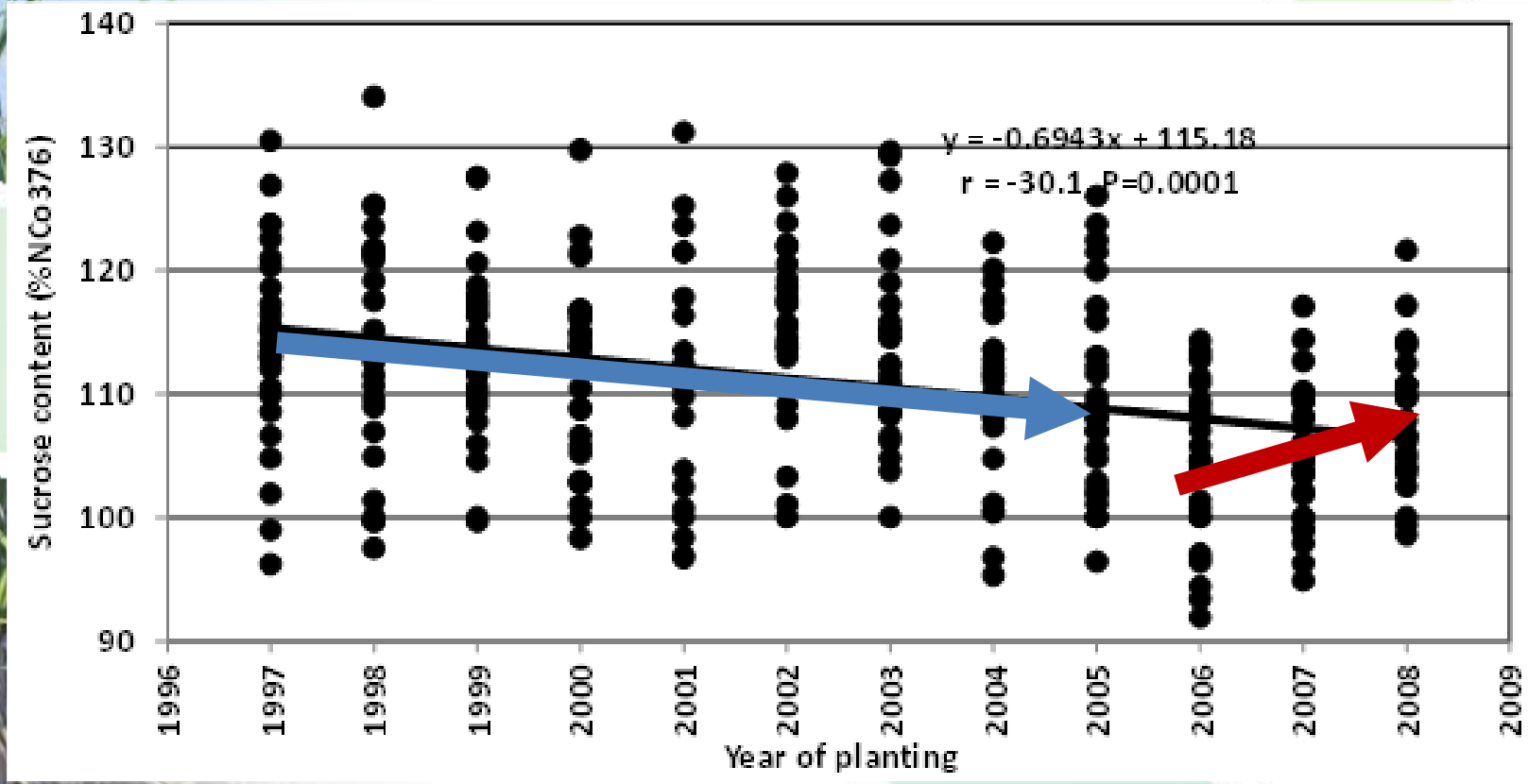
Irrigated cultivars



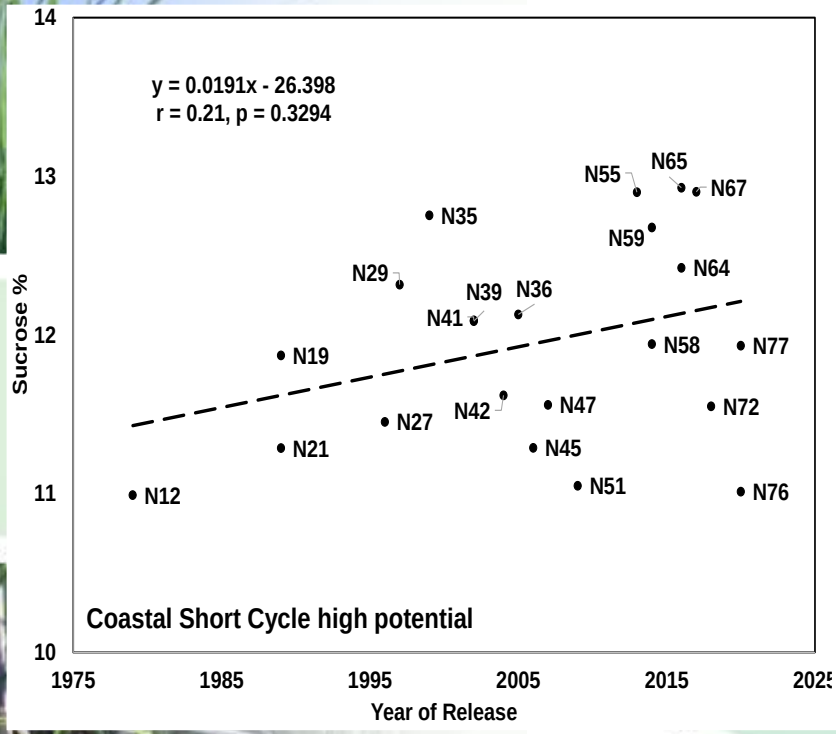


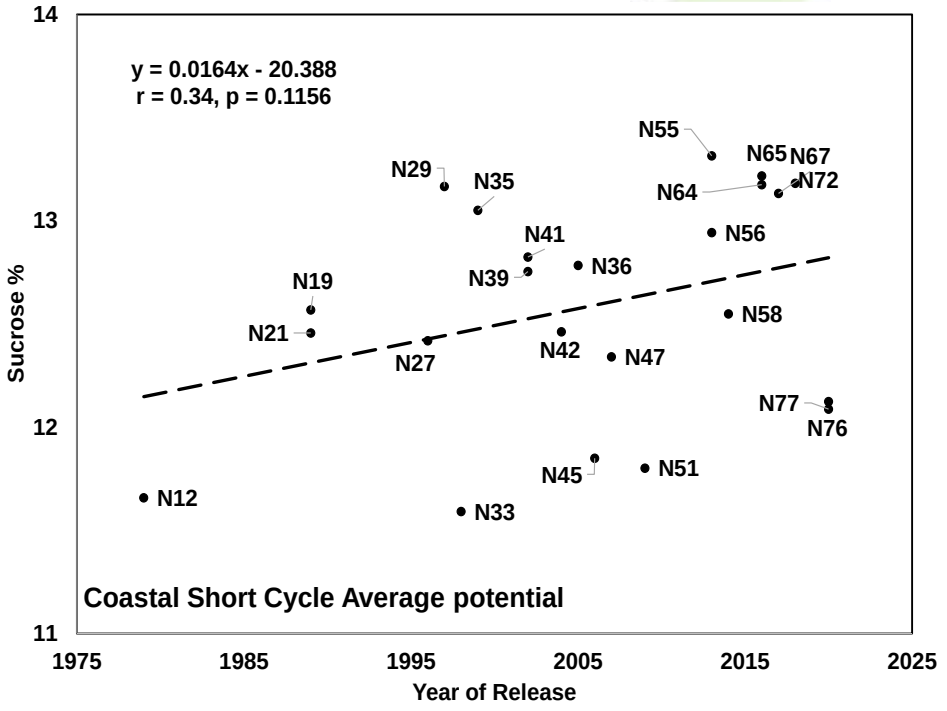
Late season confounding = early stage (1, 2, 3) populations grown and selected late season. Highlights importance of evaluating breeding strategy – confounding resolved, will enhance breeding for higher sucrose in early season

Coastal short cycle populations



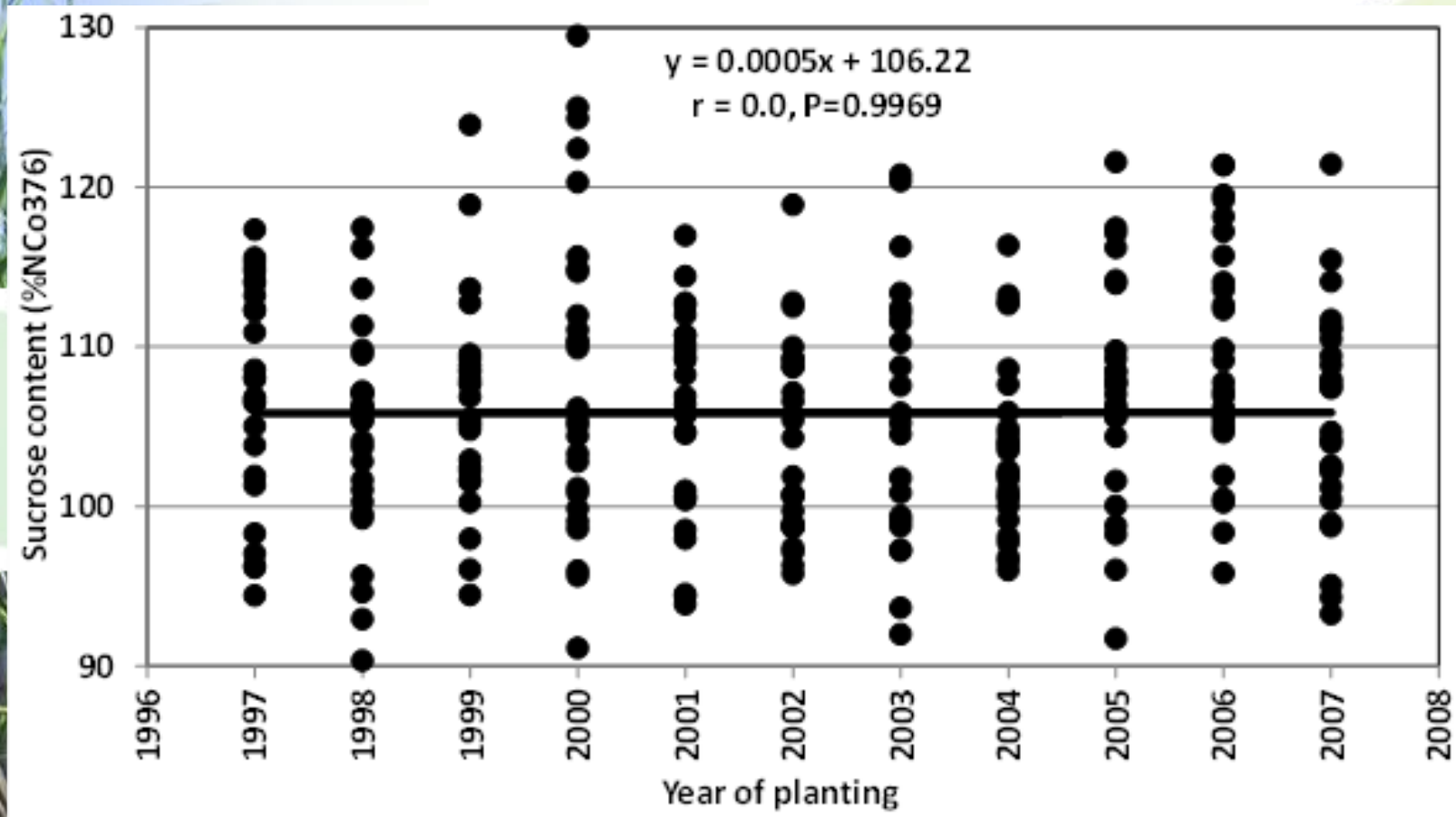
Coastal short cycle cultivars





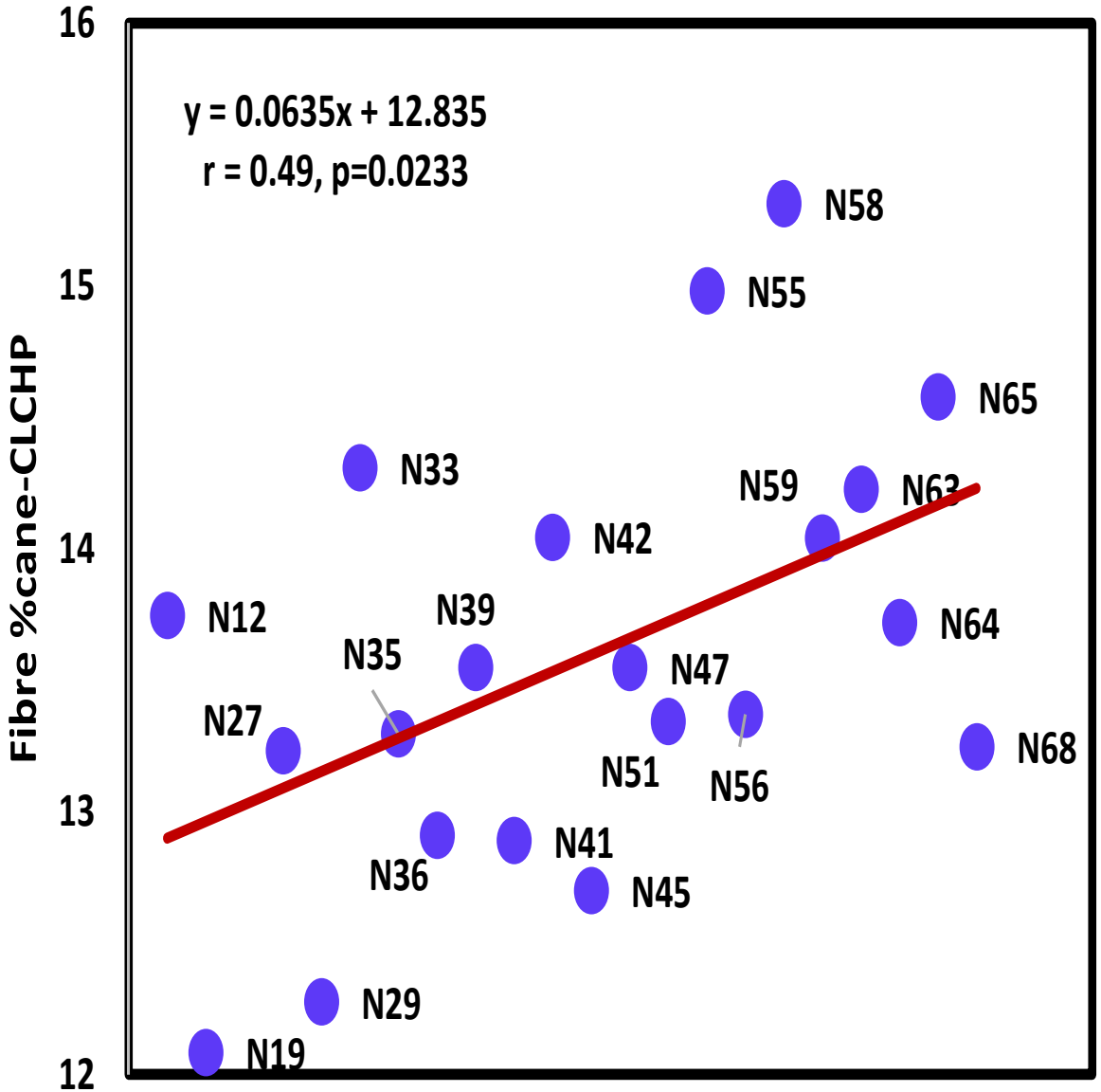
Limited/narrow genetic variability for sucrose content.

Coastal long cycle populations

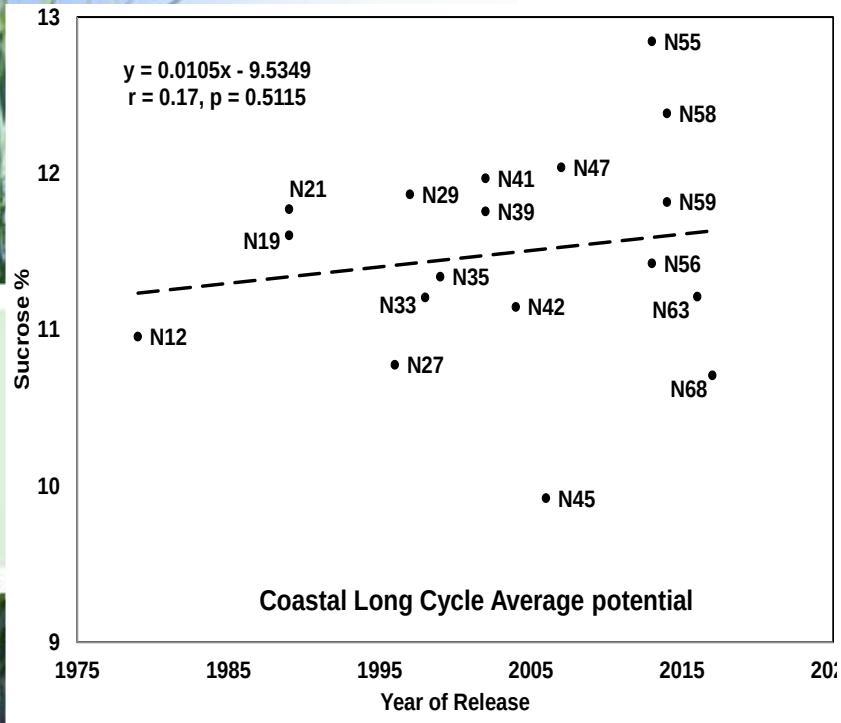


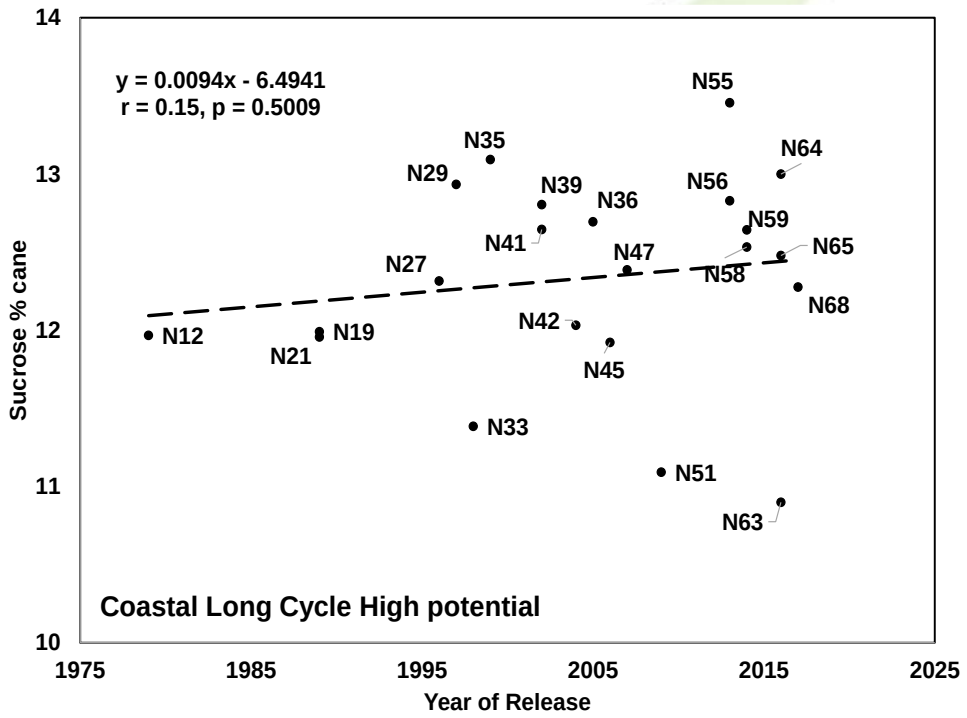
Fibre content based eldana resistance and negative genetic correlation between fibre and sucrose content + sucrose content genetic variability low

Fibre %cane and Eldana resistance breeding



Coastal long cycle cultivars

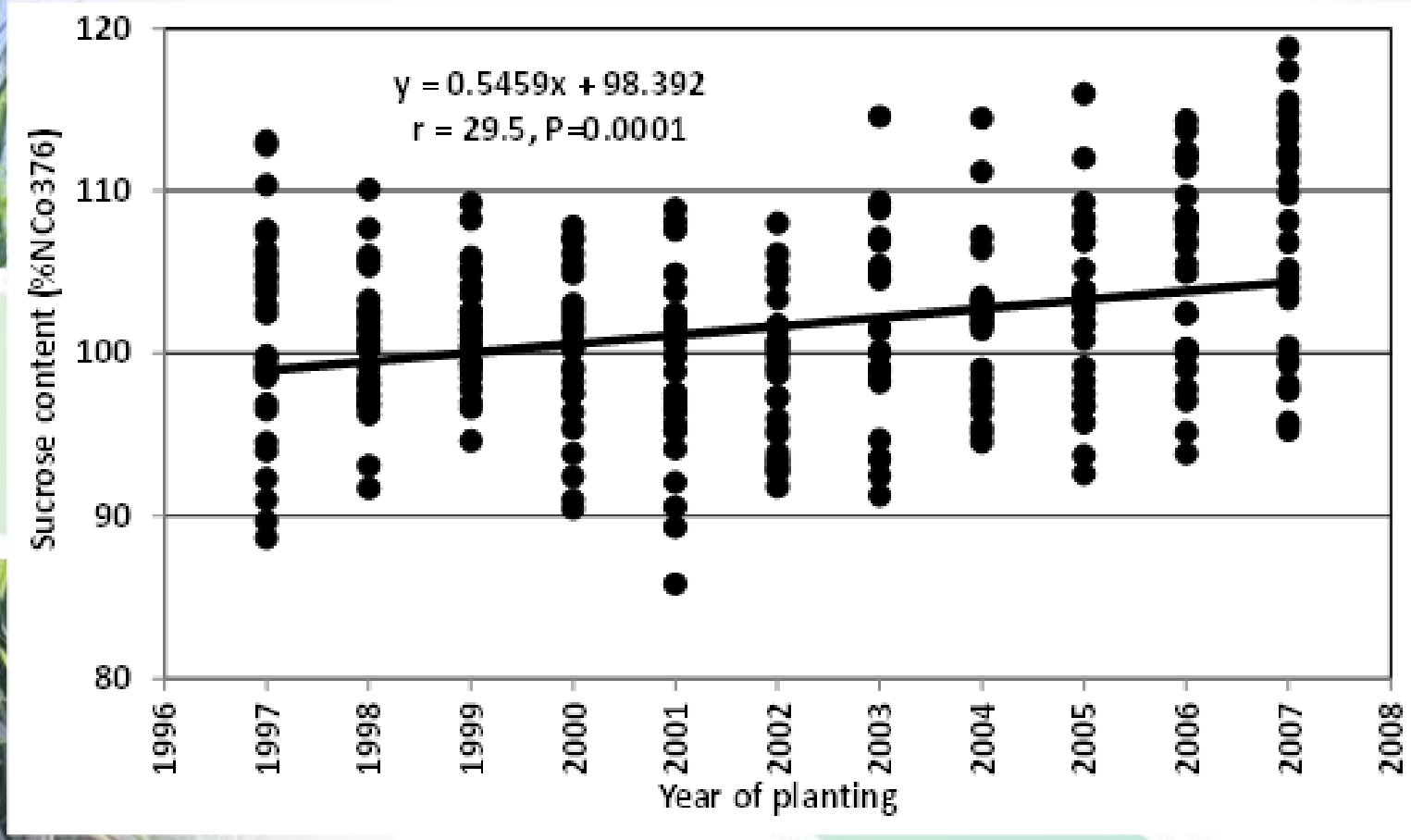




Fibre content based eldana resistance and negative genetic correlation of fibre and sucrose content

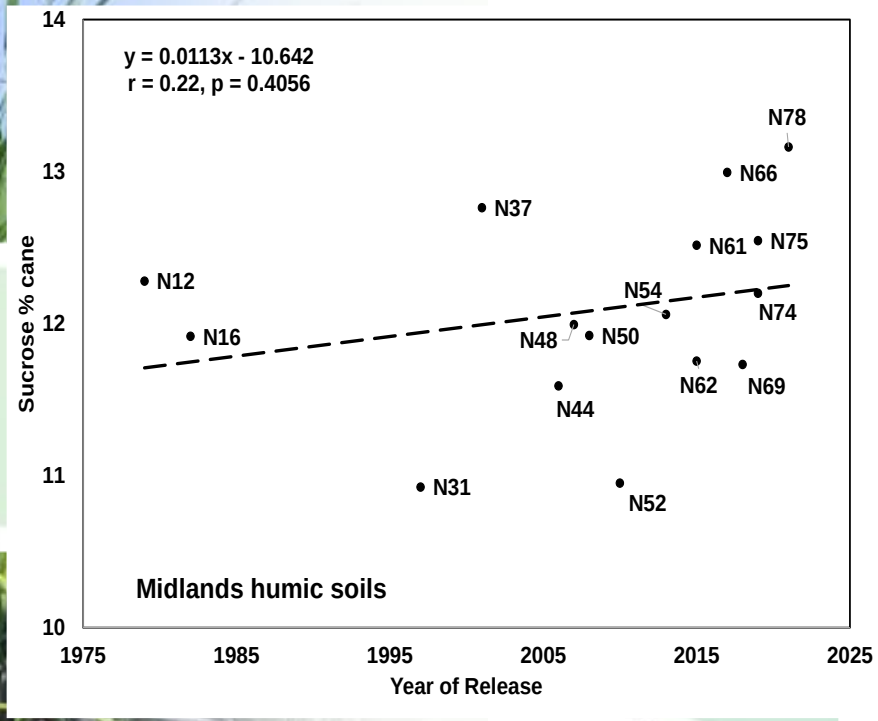
New sources of resistance required in populations and cultivars

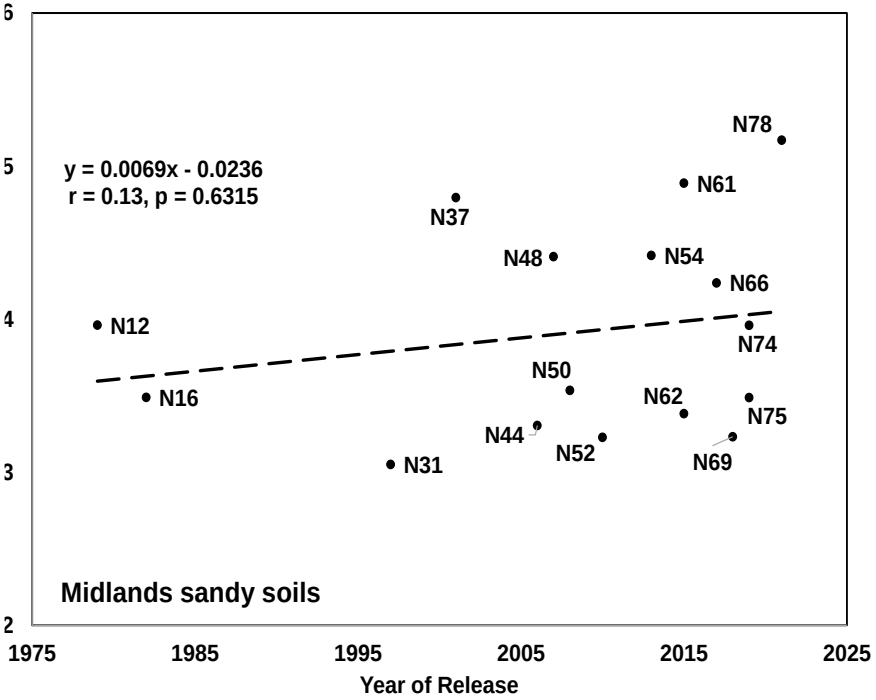
Midlands populations



Second only to irrigated, low eldana??

Midlands cultivars





Low RV in commercial crops = N66 + N78, its possible to breed high sucrose in Midlands cultivars

Adaptability to changing climate

- Adaptability to higher temperatures and higher heat units,

- Harvest at younger age for midlands,
  - Latest releases already produce higher cane yield at younger age,
  - Lower RV could be a challenge
    - High RV cultivars = N78,
    - Breed for 12 month or younger crops
    - Examples = Canal Point, Louisiana have done it.
  - Agronomy practices to match harvesting crops younger than 24 months

- Harvest at younger age for coastal long cycle,
- Harvest at younger age for coastal hinterland

Eldana damage

- Higher temperatures, droughts = higher incidence of eldana,
- Can we breed for higher eldana resistance/tolerance?
- Higher resistance could reduce gains in TCH & RV%,
- Coastal populations = high levels of resistance present,
  - Breeding for higher infestations possible,
  - SASRI resistance largely fibre based
  - Higher resistance = higher fibre,
  - Higher fibre = low sucrose (negative association)
  - Explore alternative resistance mechanisms
    - self-trashing?

- Midlands = moderate to high levels of resistance
  - Potential to increase resistance when eldana infestation increases
  - Resistance in recent cultivars appears increasing as eldana levels increase
  - Enhance breeding for eldana by developing parents in coastal areas
  - Requires investment in trait development for the populations

- Irrigated = low levels of eldana resistance
  - Populations have low levels of resistance
  - Screening irrigated populations in higher infestation areas such as coastal long cycle (GRS??) but its costly,
  - Research to develop traits for indirect breeding for eldana resistance,
    - self-trashing.
    - Use Bt gene??

Smut

- Higher temperatures increase smut infestation,
- Droughts increase survival and spread of smut spores
- The spores germinate when rain occurs or after irrigation
- Example = higher smut in Mpumalanga than Pongola, and higher smut in Zimbabwe than RSA.
- Drier environments = higher smut spore survival in soil, spores spread by wind = germinate when they reach host plants.

smut

- Can we breed for increased smut resistance?
- Low levels of resistance in Midlands populations,
- Developing parents in High smut environments will be required,
- Current early stage PB trials located in Pongola,
  - Low smut levels in these trials,
  - Low family and parent evaluation for smut,
  - Limited development of high resistant parents,
  - Knowledge of parents with high breeding values??,
  - Limited understanding of genetic control for smut infection.
  - Consider evaluating populations in Mpumalanga??
    - This approach comes with a high cost.

Arms race scenario

- Higher eldana breeding cycles driven by higher temperature (higher damage)
- need for higher resistance
- higher selection pressure for resistant strains
- higher breeding cycles for resistant strains driven by temperature
- cultivars succumbing quickly
- frequent production of higher resistant cultivars
- repeats the cycle
- an arms race situation.

Conclusion

- Breeding for higher cane yield possible but confounding from pest and diseases may reduce genetic gains,
- Genetic gains for sucrose content may decrease because of fibre based eldana resistance,
- Strategies to enhance breeding for eldana and smut will need to be explored,
  - Evaluating populations in high infestation environments,
- Breeding for YSA need to be initiated to provide more options for an IPM strategy,
- Arms race scenario with breeding for P&D!