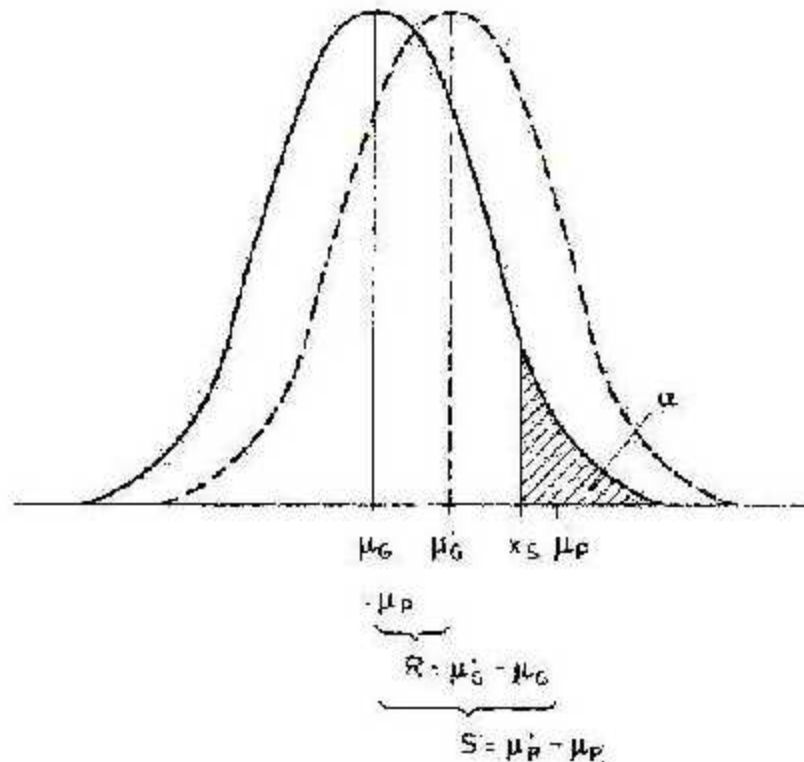




How can we measure genetic gain in our applied breeding programs (can we measure it from 1993 – 2012+ ?)

Wolfgang Grüneberg

Genetic Gain – what is this?



A little bit Selection Theory:

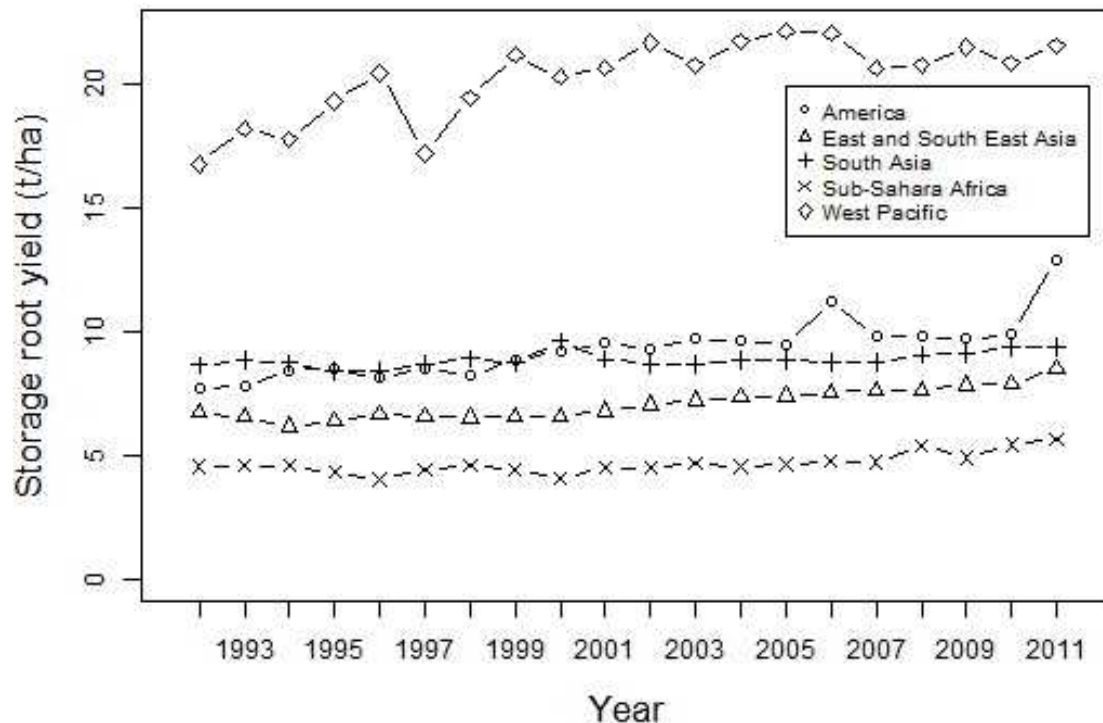
- 1) Allocation of Breeding Resource
Grüneberg et al 2004 Plant Breeding
- 2) G x E and low input environments
- 3) Multi-trait selection (Index selection)
- 4) Optimization of number of crosses
- 6) Hybrid Breeding

Figure 1: Response to selection or genetic gain – approx. by GVC; exact model calculations

Yield between families $\sigma_G^2 = 1.9 \text{ t ha}^{-1}$
 -carotene between families $\sigma_G^2 = 114 \text{ ppm}$
 Zn between families $\sigma_G^2 = 0.73 \text{ ppm}$

DM between families $\sigma_G^2 = 2.1\%$
 Fe between families $\sigma_G^2 = 1.45 \text{ ppm}$

FAOSTAT – yield increase by region 1992 – 2011 (perhaps we can come to better statistics)



Sub-Saharan Africa (SSA) still has the lowest yields compared to other world regions, but this varies extremely among countries in SSA

However, SSA had across the past 20 years 1% yield increase per year across all SSA countries, although a lot of marginal soils came into use.

Figure 2: Annual sweetpotato storage root yields in t/ha by regions (FAOSTAT 2011)

America considering Argentina, Brazil, Cuba, Haiti, Peru and United States of America

Sub-Saharan Africa considering East-Africa with Burundi, Ethiopia, Kenya, Rwanda, Uganda and United Republic of Tanzania, Southern Africa with Angola, Madagascar, Malawi, Mozambique, and Zambia, and West-Africa with Nigeria, Ghana and Mali;

South Asia considering Bangladesh and India;

East and South East Asia considering Indonesia, Papua New Guinea, Philippines and Viet Nam;

West Pacific considering China, Korea and Japan.

Genetic gain

Yield progress examples.

Can 2 to 3% gain be reached per year?

Yes – but depends can be proof this?

Genetic gain is always comparing old with new varieties
But different levels or point of historically, experimentally, on-station, on-farm

Classic examples:

- a) Oat (*Avena sativa*) landrace 200 years old
- b) Long term maize selection for 100 generations (protein and oil)

Checks: Cemsa, Dagga, Resisto, Tanzania

Predominantly grown varieties:

- past (20 years ago) and current predominantly grown varieties

Country	2002	2009	2011
Argentina	14.6	13.8	15.1
China	21.7	21.6	21.7
Ghana	1.4	1.6	1.8
India	8.6	9.0	9.3
Indonesia	10.0	11.2	12.3
Japan	25.4	25.3	22.8
Kenya	8.5	12.0	12.3
Mali	15.8	19.1	18.8
Mozambique	5.7	7.1	7.7
Nigeria	3.0	2.9	2.9
Peru	16.1	16.4	18.1
Philippines	4.5	4.9	5.0
USA	17.4	22.5	23.3
Uganda	4.4	4.5	4.8
Zambia	17.0	15.4	18.4

Genetic gain - experimentally

Heterosis experiment Peru

80 parents

Heterosis experiment Uganda

16 parents

Secure base line – these parents go into the bank !!!

Polycross versus controlled cross experiment 22 parents (mega clones) but this was also a ABS (accelerated breeding scheme) **without discarding material for one selection step** (what is the observed response to selection or observed genetic gain)

Comment: Response to selection or genetic gain has a large biological error – it's a function of heritability and number of candidates in the selected fraction



Figure 3. Planting the ABS at San Ramon – plot size 1m row, no replication, 2 to 3 locations

Genetic gain – under farm practice

Series of multi-environmental trials (METs) usually over 2 to 3 years

For example **5 years SASHA I then 3 MET sets are possible** – these can serve a) **variance component estimations** in later breeding stages b) the genetic gains (development of the mean in these METs) during these time period
Comment: this is still a small section of the long term genetic gain – 10 or 20 years)

In practice 10 to 20 years of METs from variety release time using 8 to 18 METs allows to estimate long term yield trends and changes in long term yield trends (by some kind of regression analysis or plots of year and/or genotype means against time - assess time trends) including gain components due to better practice



Figure 4. Variety release trials under farm practice Serere / Uganda 2008.

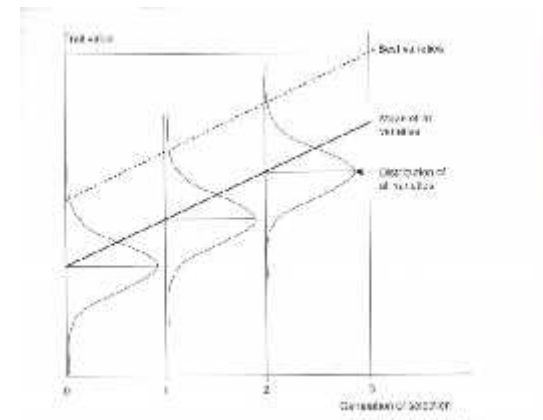


Figure 5. Long term genetic gains from Gallais 2003.

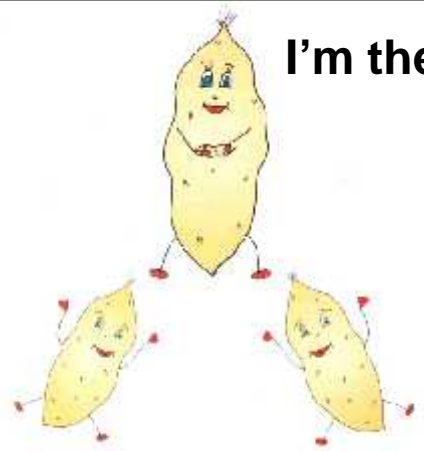


Literature - Gain under farm practice

Schuster et al. 1977;
Silvey 1978, 1981, 1986;
Wricke and Weber 1986 (chapter: Breeding progress and selection limits
– copy available)
Perry and D'Antuono 1989;
Schuster 1997;
Peltonen-Sainio et al. 2009;
Ahlemeyer and Friedt 2011;
Mackay et al. 2011;
Lopes et al. 2012);
Piepho et al 2013 – copy available).



I'm the gain



Thank-you for your Attention