TRAINING IN ORGANIC BREEDING!

Module 5 - Organic heterogeneous material (OHM) design and development
MARCH 7th 2025, 9:00 to 18:00 CET

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Unit 5.1: Composite Cross Populations: setting-up & selection
- 9:00-11:00 - UPV (A. Rodriguez-Burruezo) + INRAe (Isabelle Goldringer)

- 11:00-11:30 Break

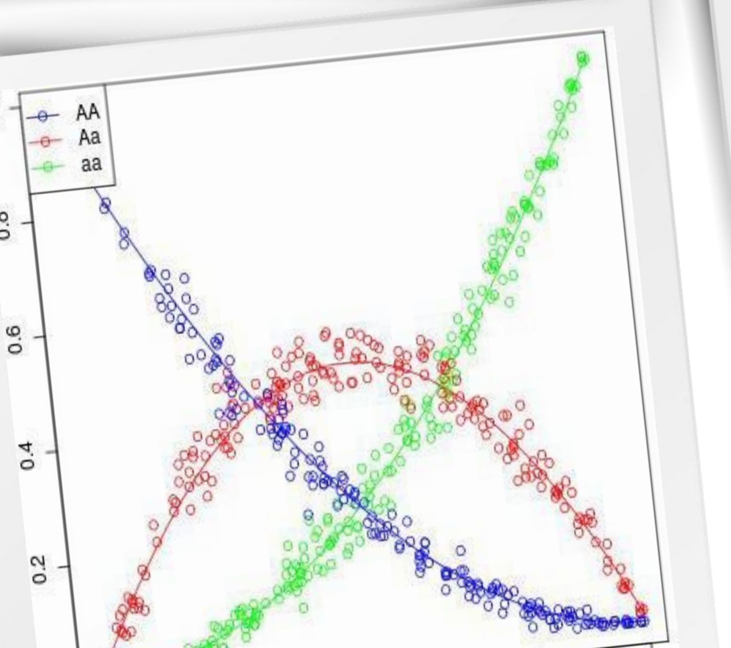
Unit 5.2: Dynamic Mixtures: setting-up & selection
- 11:30-13:00 - IPC (Pedro Mendes Moreira)

- 13:00-14:30 Lunch Break

Unit 5.3: Fundamentals of populations genetics applied to OHM development and use
- 14:30-16:00 - UPV (A. Rodríguez-Burruezo) + INRAe (Isabelle Goldringer)

- 16:00-16:30 Break

Unit 5.4: Using genomics to track the evolution of heterogeneous organic materials
- 16:30-18:00 - FiBL (Michael Schneider)



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Training in organic breeding

Module 5: Organic heterogeneous material (OHM) design&development

Unit 5.3: Fundamentals of populations genetics applied to OHM development and use

Authors: A. Rodríguez-Burruezo (UPV), I. Goldringer (INRAe)

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UK Research and Innovation

Module 5 – Unit 3 Fund. populations genetics

IMPORTANT

1. *Questions through the chat*

2. *FOR CERTIFICATES:*

   2.1. Quiz (10 min)

   2.2. Home work (next Friday14th March)

   SEND TO ME adrodbur@doctor.upv.es

   and Ananmarija Coric (IPS) anamarija.coric@ips-konzalting.hr

Module 5 – Unit 3 Fund. populations genetics

Things to be treated today

1. *Genetic structure basics*
2. *Evolution with reproductive systems*
   - *2.1. Autogamous*
   - *2.2. Allogamous*
3. *Microevolutionary forces*
4. *Practical example: PopGen server (Radford Univ.) **
5. *QUIZ (10 min)*
6. *Wrap up, take home messages and *homework (about 5 min)*

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Genetic structure basis

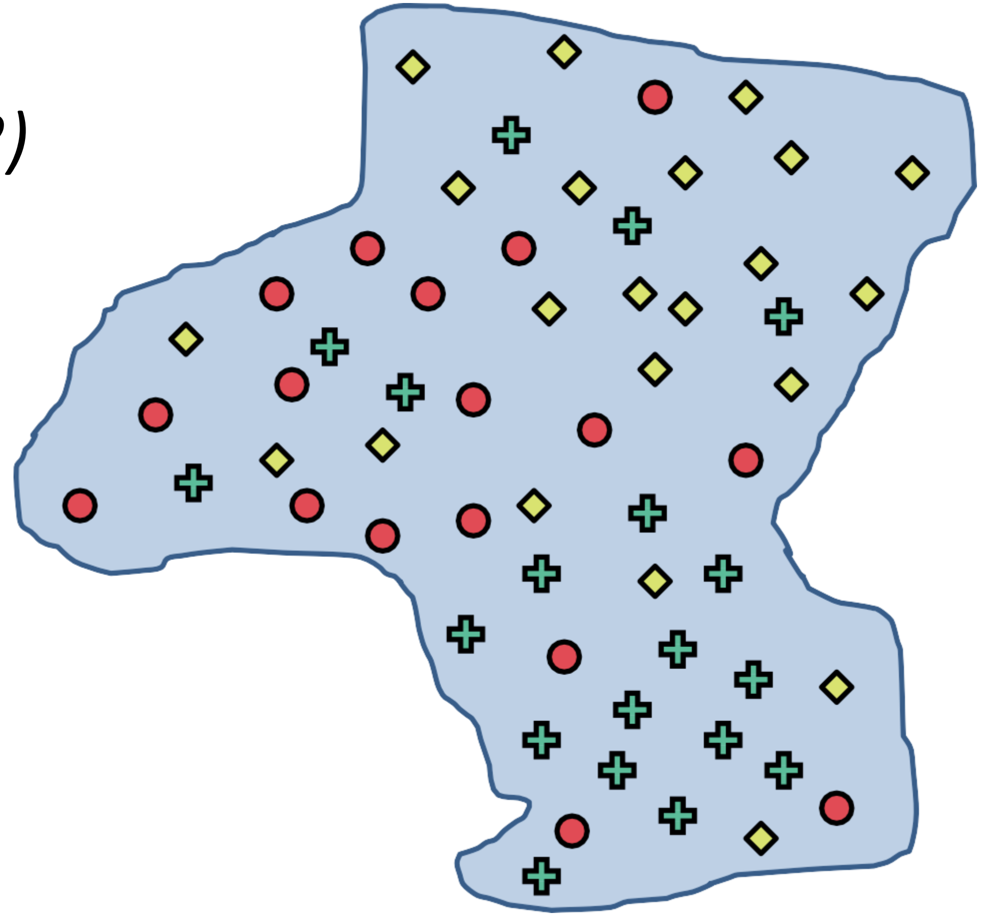
- ❑ *Very Basic: 1 gene A & 2 alleles (a1 & a2)*
- ❑ ***Genotype** and **allele** frequencies*

Genotypes

a1a1 ●

a1a2 ◇

a2a2 ✚



- ➢ **N_{11}: nº *a1a1***
- ➢ **N_{12}: nº *a1a2***
- ➢ **N_{22}: nº *a2a2***
- ➢ **$N_T = N_{11} + N_{12} + N_{22}$**

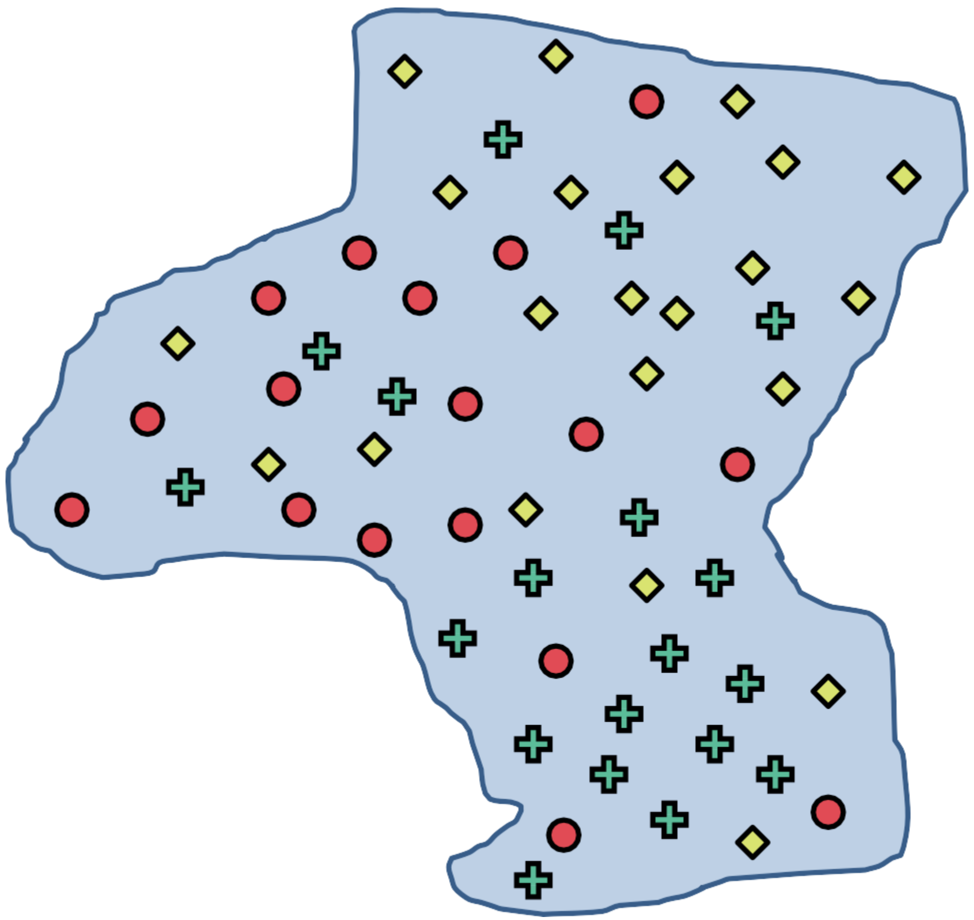
Genetic structure basis

Genotype frecuencies

- $F(a1a1) = N_{11}/N_T$
- $F(a1a2) = N_{12}/N_T$
- $F(a2a2) = N_{22}/N_T$

Allele/gene frecuencies

- $F(a1) = (2 \times N_{11} + N_{12})/2 \times N_T$
- $F(a1) = F(a1a1) + 1/2 \times F(a1a2)$
- $F(a1) = p$
- $F(a2) = (2 \times N_{22} + N_{12})/2 \times N_T$
- $F(a2) = F(a2a2) + 1/2 \times F(a1a2)$
- $F(a1) = q$



Genetic structure basis

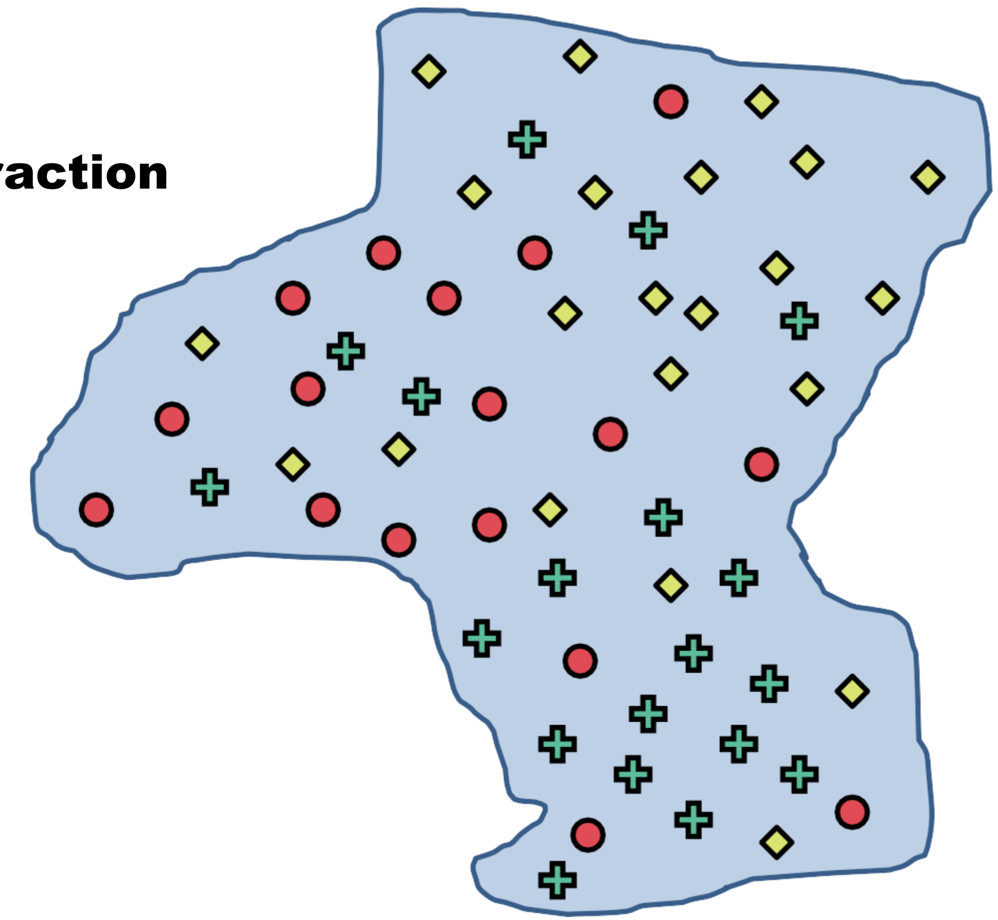
Phenotype frecuencies…depend on allele interaction

Dominance: a1 > a2

- ***a1a1* = *a1a2* ≠ *a2a2***
- **FP*a1* = F(*a1a1*) + F(*a1a2*)**
- **FP*a2* = F(*a2a2*)**

Co-dominance, partial dominance, intermediate inherinatce, etc:

- **No dominance between *a1 vs a2***
- ***a1a1* ≠ *a1a2* ≠ *a2a2***
- **Each genotype one phenotype**



Genetic structure basis

Multiallelism… What if not only a1, a2, but also a3, ….?

Genotype frecuencies

- $F(a1a1) = N_{11}/N_T$
- $F(a1a2) = N_{12}/N_T$
- $F(a1a3) = N_{13}/N_T$
- $F(a2a2) = N_{22}/N_T$
- $F(a2a3) = N_{23}/N_T$
- $F(a3a3) = N_{33}/N_T$

Allele/gene frecuencies

- $F(a1) = (2 \times N_{11} + N_{12} + N_{13})/2 \times N_T$
- $F(a1) = F(a1a1) + 1/2 \times F(a1a2) + 1/2 \times F(a1a3)$
- $F(a1) = p$

- $F(a2) = (2 \times N_{22} + N_{12} + N_{23})/2 \times N_T$
- $F(a2) = F(a2a2) + 1/2 \times F(a1a2) + 1/2 \times F(a2a3)$
- $F(a2) = q$

- $F(a3) = (2 \times N_{33} + N_{13} + N_{23})/2 \times N_T$
- $F(a3) = F(a3a3) + 1/2 \times F(a1a3) + 1/2 \times F(a2a3)$
- $F(a3) = r$

Evolution with reproductive systems

Autogamous species (strict)

	AA	Aa	aa
F1	0	1	0
F2	0,25	0,5	0,25
F3	0,375	0,25	0,375
F4	0,4375	0,125	0,438
F5	0,4688	0,0625	0,469
F6	0,4844	0,0313	0,484
F7	0,4922	0,0156	0,492
F8	0,4961	0,0078	0,496
F9	0,498	0,0039	0,498
F10	0,499	0,002	0,499
F11	0,4995	0,001	0,5
F12	0,4998	0,0005	0,5
Fn	0,500	0,000	0,500

Let´s be symple again!!! 1 gene & 2 alleles

TREND: at the end a mixture of homozygous individuals = inbred lines
2 genotypes per gene (AA and aa)

Heterozygous very rare (with some cross pollination) or dissapear

AABB
AAbb aaBB aabb
aaBBcc aabbcc aabbCC
AAbbCC AABBCC
AaBBcc ..... etc

Evolution with reproductive systems

Allogamous species (strict)

On each generation, all the individuals cross among them (panmixia)

On a ideal situation:
Infinite populations
All cross with all randomly
No microevolutionary forces

AaBBCc
AABbcc aABBCc aabb
AaBbcC
aABbCC AaBbcc
AaBBCc ..... etc

Hardy-Weiberg law:

F(a1a1) = p2 F(a2a2) = q2 F(a1a2) = 2·p·q
Donde p = F(a1) , q = F(a2) y p2 + q2 + 2·p·q =1

TREND:
in just one generation the population reaches the equilibrium.
With genotype frequencies p2 + q2 + 2·p·q =1
A mixture of homozygous and heterozygous individuals (3 genotypes per gene)
More diverse populations
Better against nature´s selection

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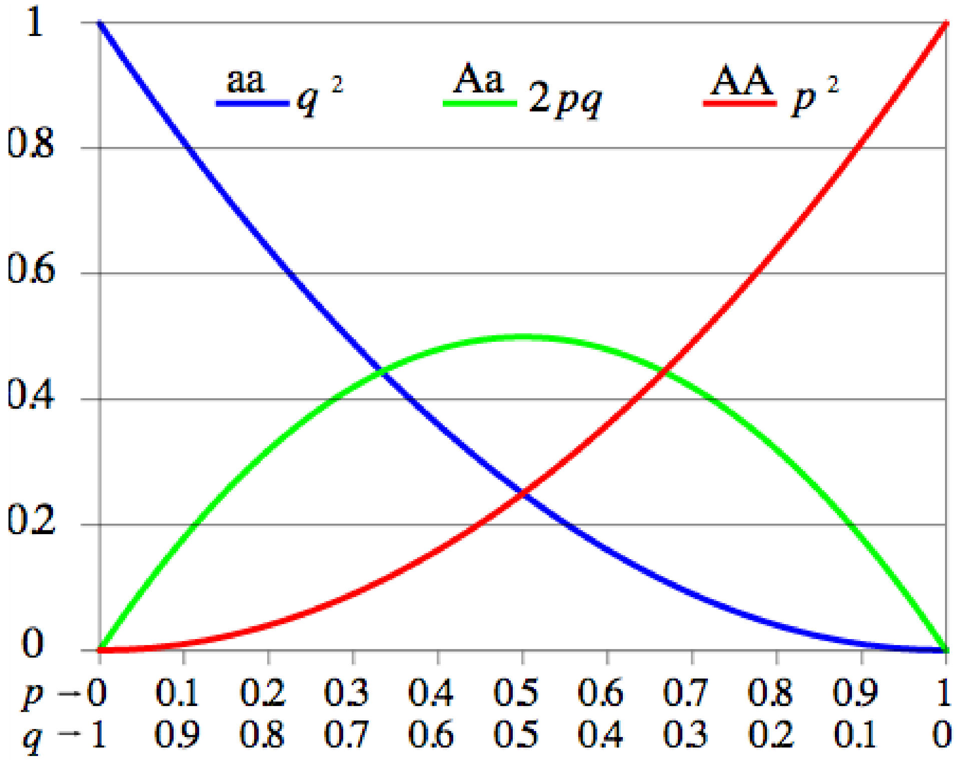
Evolution with reproductive systems

Allogamous species (strict)

Hardy-Weiberg law:

F(a1a1) = p2 F(a2a2) = q2 F(a1a2) = 2·p·q
Where p = F(a1) , q = F(a2) y p2 + q2 + 2·p·q =1

Example:
Population with frequencies 0.20, 0.40 and 0.40 for a1a1, a1a2 and a2a2
1. gene frecuencies?
2. How in next generation the genotypic and allele frequencies?



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Evolutionary forces: 4 horsemen of the apocalypse

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Evolutionary forces: 4 horsemen of the apocalypse

ON THE WHOLE….

- ***Nature selection*** *(and/or breeder´s) affects differently the genotypes and modify their frequencies* ***"fitness"*** *Decreases diversity*
- ***Genetic drift*** *effect of population size Decreases diversity*
- ***Mutation*** *Increases diversity*
- ***Migration*** *Decreases when individuals leave*
  Increases when new individuals arrive

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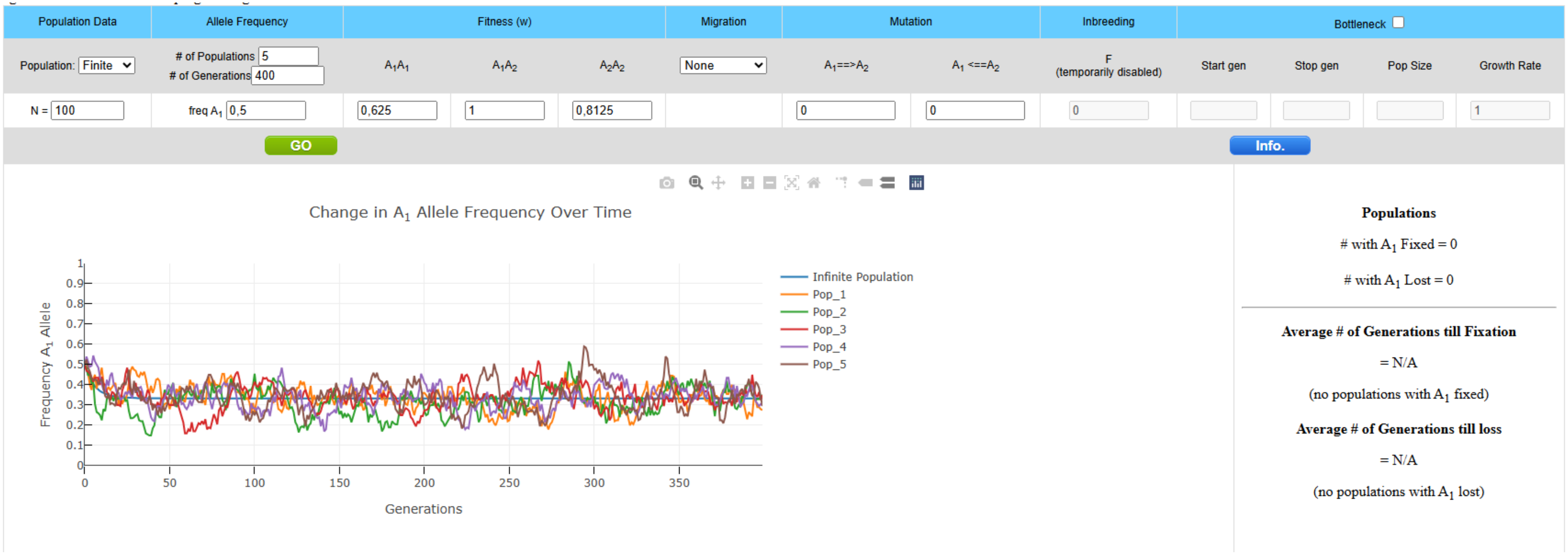
Let´s practise

Practical example: PopGen server (Radford Univ.)

https://sites.radford.edu/~rsheehy/Gen_flash/popgen/



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QUIZ (10 min)

- *What kind of population is expected in highly autogamous crops?*
- *And what about in highly allogamous (cross-pollination) crops?*
- *Which reproductive system provides higher adaptability and resilience?*
- *How selection affects genetic structure of a population?*

Send to: adrodbur@doctor.upv.es and anamarija.coric@ips-konzalting.hr

IMPORTANT FOR CERTIFICATES!!!!

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What we have learned today?

- *DIVERSITY = RESILIENCE*
- *Autogamy, inbreeding = decreases diversity towards inbred lines and heterozygous disappearing*
- *Allogamy = increases/keeps diversity by recombining genes*
- *Other intermediate cases*
- *Nature selection: hard evolutionary force (and helpful in breeding)*

Homework: *practise with PopGene server, combine different evolutionary forces and send 3 screenshots and their interpretation (by next Friday 14th)*

Send to: adrodbur@doctor.upv.es and anamarija.coric@ips-konzalting.hr

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ADDITIONAL MATERIAL

Practical example: PopGen server (Radford Univ.)

https://sites.radford.edu/~rsheehy/Gen_flash/popgen/

T1.4 Training in Organic Breeding

Module 5: Organic heterogeneous material (OHM) design & development

Unit 3 – Fundamentals of populations genetics applied to OHM development & use

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