9. Wissenschaftstagung Ökologischer Landbau.
Beitrag archiviert unter http://orgprints.org/view/projects/wissenschaftstagung-2007.html

Interaktionen zwischen Genotyp und Ort sind ein Vorteil von lokaler Züchtung von Ackerbohnen (*Vicia faba* L.)

Genotype × location interactions are advantageous for local breeding of faba bean (*Vicia faba* L.)

L. Ghaouti[1], W. Vogt-Kaute[2] und W. Link[1]

Keywords: development of organic agriculture, faba bean (V*icia faba* L.), genotype × location interaction, local breeding

Schlagwörter: Entwicklung Ökolandbau, Ackerbohne (V*icia faba* L.)

Abstract:
Organic farming is based on low productivity environments regarding the restricted supply of inputs. Thus, to maximize the response of selection, the local breeding approach was put forward for organic agriculture. To analyse this approach, efforts of organic farmers and scientists were combined in a pertinent, participatory breeding approach using spring faba bean as crop. A set of genotypes with different levels of heterozygosity and heterogeneity were tested in four organic farms and one conventional location. Results for grain yield showed that the genotype-location interaction was highly significant and contributed to a large extent to the yield variation. The findings indicated that indeed local breeding programs could give greater genetic gains for organic cropping systems than traditional, formal plant breeding programs.

Introduction and Objectives:
Breeding programs develop cultivars for deployment in a target environment. The target environment may be broadly or narrowly defined in terms of biotic and abiotic parameters (ATLIN et al. 2001). Formal plant breeding programs have mainly focused on the production of input responsive and broadly adapted cultivars that show high performance over a wide range of environments. Genotype × environment interactions occur if the relative performance of genotypes, compared with each other, depends on the actual environment. Therefore, in cases where marginal areas are included, the genotype × environment interactions tend to be large and formal plant breeding will often fail to breed the appropriate germplasm. Organic production is similar to marginal areas production with rather heterogeneous environments, large diversity of farmer´s needs and lack of adapted varieties (DESCLAUX 2005). Local breeding allows to make use of the genotype × location interaction and thus to increase gain from selection. Cultivars offered by formal plant breeding have to be “distinctive, uniform and stable”, whereas on the contrary, organic breeding launched the concept of ongoing genetic evolution and adaptation of a local cultivar for its specific target region. The objective of this study was to start an investigation into a local breeding approach for German organic conditions in spring faba bean (*Vicia faba* L.).

Material and Methods:
Spring bean genotypes (N=49) with different degree of heterogeneity and heterozygosity were used in replicated field trials across four organic locations and one conventional location in Germany in 2004 and 2005. The agro-ecological

[1]Gesellschaft für wissenschaftliche Datenverarbeitung mbH, Am Fassberg, 37077 Göttingen, Deutschland, lghaout@gwdg.de
[2]Naturland e.V., Kleinhadener Weg 1, 82166 Gräfelfing, Deutschland

conditions of the locations are diverse: Tröndel (Trö) near Kiel, Ramsthal (Ram) near Bad Kissingen, Willmering (Wil) near Regensburg and two further locations belonging to our Department´s experimental stations: Deppoldshausen (Dep) and Reinshof (Rei). Reinshof is a conventional site. Eighteen homozygous inbred lines were used *per se* and to produce 18 corresponding polycross progenies, several checks were included in addition. Mean values and variances of the lines and their polycross progenies for grain yield were assessed in each location and in a combined analysis across locations.

Results and Discussion:

The combined analysis of variance across locations, years and genotypes showed that for grain yield all sources of variation were significant (Tab. 1). Genotype × environment interactions were large (the pertinent variance components were GY+ GL+ GYL = 0.41 t^2/ha^2) which is about twice the variation of the genotypic variance component (0.21 t^2/ha^2). Genotype × location interactions (GL) contributed (0.15 t^2/ha^2) more than half as much as the genotypes (0.21 t^2/ha^2) to the yield variation.

Tab. 1: F-values of the different sources of variation for grain yield (t/ha); combined ANOVA across genotypes, locations and years.

Sources of variation	Grain yield (t/ha)			
	Degrees of freedom	Variance components	F value	LSD 5%
Locations (L)	4	1.68	529.78**	0.16
Years (Y)	1	0.57	447.84**	0.10
Genotypes (G)	48	0.21	7.84**	0.49
YL	4	0.90	143.05**	0.22
GL	192	0.15	1.96**	1.10
GY	48	0.11	2.69**	0.70
GYL	190	0.15	1.93**	1.12
Error	361	0.16	-	-

* Significant for P<0.05; ** Significant for P<0.01

Two so-called genotypic structures were involved in the trial. First of all, inbred lines, being single, homozygous and therefore genetically fixed genotypes, they show maximum uniformity and a pointed, clear phenotypic expression. Testing the adaptation of a collection of inbred lines for a given environment, hence, opens the option to find a specifically adapted line; whereas secondly, their polycross progenies are heterogeneous and partly heterozygous stocks, thus giving individually the option to locally evolve and become steadily better adapted over time. To display which of the two genotypic structures is a more adequate choice for local organic breeding, this comparison between the inbred lines and their polycross progenies was conducted (Tab. 1).

Local breeding is based on a direct selection in the target locations; whereas the formal breeding is based on an indirect selection, where the environments of selection are only a more or less representative sample of the target environments. Therefore the local breeding is making use of location-wise data whereas the formal breeding is relying on a combined analysis across all locations.

Results showed (Tab. 2) that among and across all locations, the differences between the polycross progenies as well as the differences between the inbred lines were highly significant.
Among locations, the performance of the inbred lines was more or less correlated with the performance of their polycross progenies (e.g, in the location "Reinshof", r = 0.73* and in Ramsthal, r = 0.06). In the combined analysis, the correlation between the inbred lines and their polycross progenies was highly significant (r = 0.76**).
As expected, due to heterosis, the polycross progenies yielded on average higher than the inbred lines (4.25t/ha > 3.46t/ha); whereas the variance among inbred lines was higher than the polycross progenies variance for both approaches (local and formal). In a local breeding approach, the exploitable variance is the genetic variance in a specific location, where the interaction between genotypes and this location is included (e.g., in the location "Deppoldshausen": δ^2(IL) = 0.27 t²/ha²; δ^2(PP) = 0.16 t²/ha²).
The average value of the variances across individual locations displays the exploitable variance for a typical single location (for inbred lines, δ^2 = 0.29 t²/ha²; for polycross progenies, δ^2 = 0.15 t²/ha²).
In local plant breeding, the variances estimated in each location as well as the average of the variances across locations were markedly higher than the variance that can be used in formal plant breeding, estimated from the mean values of yield over locations (for inbred lines: 0.29 t²/ha² > 0.14 t²/ha²; for polycross progenies: 0.15 t²/ha² > 0.04 t²/ha²).
The messages from these data are similar for all locations and both, inbred lines and polycross progenies. The variance used in the formal plant breeding is narrow compared to the variances at the typical single location, which is used in local breeding. The greater the genotype × location interaction effect is, the higher is the efficiency of local breeding compared to the formal plant breeding.

Tab 2: Mean values, phenotypic variances with its significance and least significant differences for yield (t/ha) of inbred lines and polycross progenies.

Locations (2004 and 2005)	Inbred lines (IL)			Polycross progenies (PP)			Correlation (IL, PP)
	μ	δ^2	LSD	μ	δ^2	LSD	
Local breeding approach							
Tröndel	4.16	0.19**	0.66	5.05	0.14**	0.75	0.33
Deppoldshausen	3.60	0.27**	0.86	4.45	0.16**	0.83	0.49*
Reinshof	4.65	0.33*	1.20	5.63	0.19*	0.79	0.73**
Ramsthal	1.64	0.35*	1.15	1.95	0.14*	0.90	0.06
Willmering	3.35	0.32**	0.64	4.17	0.14**	0.44	0.71**
Average	3.46	0.29	-	4.25	0.15	-	-
Formal breeding approach							
Combined analysis	3.46	0.14**	0.44	4.25	0.04**	0.36	0.76**

* Significant for P<0.05; ** Significant for P<0.01

Conclusions and Outlook:

Cultivars in faba bean rely on three types: inbred lines, synthetics and populations.
On the basis of the studied material, further experiments (2006) and analyses will allow comparing the relative excellence of two types of cultivars for local and formal

breeding: inbred lines and synthetic cultivars. The behavior of the synthetics will be predicted from the performance of the inbred lines and their polycross progenies, following pertinent quantitative genetic concepts (LINK & EDERER 1993).

Acknowledgments:
We acknowledge the support by BLE/BMVEL sponsoring this research (03OE43).

References:

Atlin G. N., Cooper M., BjØrnstad Å. (2001): A comparison of formal and participatory breeding approaches using selection theory. Euphytica 122:463-475.

Desclaux D. (2005): Participatory Plant breeding Methods for Organic Cereals. In: Lammerts Van Bueren, E.T. and Ostergard, H., Eds. Proceedings of the SUSVAR/ECO-PB Workshop on Organic Plant Breeding Strategies and the Use of Molecular Markers, p. 17-23.

Link W., Ederer W. (1993): The concept of varietal ability for partially allogamous crops. Plant Breeding 110:1-8.